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AMERICAN
PRACTICE OF SURGERY

A COMPLETE SYSTEM OF THE SCIENCE AND
ART OF SURGERY, BY REPRESENTATIVE SURGEONS OF THE UNITED STATES AND CANADA

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OF NEW YORK CITY

COMPLETE IN EIGHT VOLUMES

Profusely Illustrated

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PART XIII.

(Continued.)

DISEASES AND INJURIES OF JOINTS.

DISLOCATIONS.

By EMMET RIXFORD, M.D., San Francisco, California.

GENERAL CONSIDERATIONS.

A Dislocation is commonly defined as a permanent displacement of the articular ends of the bones forming a joint. Most writers insist upon the word "permanent" in the definition, in order to distinguish between the displacements which persist and those which are but momentary, classifying the latter injuries as sprains.

The term Dislocation is conventionally limited, so far as the bony framework of the body is concerned, to such displacements as occur in perfect or complete joints (diarthroses), while the term Diastasis (standing apart) is used to designate traumatic displacements in the so-called imperfect or "half" joints, such as the sacro-iliac synchondroses, the symphysis pubis, and the joint between the manubrium and the remainder of the sternum (amphiarthroses), and occasionally in the fixed joints (synarthroses). Traumatic separation of the epiphyses from the shaft or body of a bone is also commonly called a diastasis, but, since these lesions and the displacements in the fixed joints are more allied to fractures, they are classified and described with them rather than with the dislocations. In diastases the displacement is often at right angles to the plane of the articular surfaces, permitting a considerable degree of lateral mobility in various directions; and, while reduction may be effected in these cases by simple pressure, retention may be most difficult.

Clinically a sharp distinction is to be made between a complete dislocation (luxation) and a partial (subluxation), for in the former the displacement is so great that the articular surfaces have completely slipped by each other and remain in contact only by their opposite edges, in which position and by reason of this very "slipping by" of their articular ends the bones are locked in a position of equilibrium. The ligaments, tendons, etc., which have escaped rupture are for the most part relatively more relaxed than at the moment when the dislocation passed from the limits of partial dislocation and became complete. As a result of this relaxation of ligaments, there is permitted in most complete dislocations a certain degree of motion. Pathologically the differences between partial and complete dislocations are slight, being simply those of degree; ligaments are more widely torn and periosteum more extensively stripped from the bone in the latter.

Dislocations are commonly divided etiologically into three great classes—congenital, pathological, and traumatic,—the first being present at birth and accompanied by, if not the result of, defective development; the second, the result of disease by which the contour of the articular ends of the bones or the resistance of the ligaments which limit the motions of a joint are so altered as to permit of displacement occurring with little or no force applied; and the third being produced by trauma in a substantially normal joint.

As are fractures, so dislocations are said to be simple or complicated,—a distinction which is convenient and of practical value,—but between the two there is no sharp line of demarcation. In the simplest dislocation there is some damage done the neighboring tissues—ligaments are stretched or torn, periosteum is stripped up—and an infinite number of degrees of such damage may exist. The complications which are commonly considered in this connection are fracture, epiphyseal separation, laceration or pressure paralysis of nerves and injury to blood-vessels, tendons, muscles, etc., in proximity to the joint. It should not be overlooked that a complication related to some other part of the body may attend or follow dislocation and be the graver condition.

Dislocations are also divided into subcutaneous, or simple, and compound, indicating non-exposure or exposure to the air—an old distinction antedating exact knowledge in the field of infection. It has been suggested that "infected" would be a preferable term to "compound" as better expressing the distinction. While the word "compound" in itself does not express any pathological distinction, common usage would seem to require its retention, for while an open fracture or a dislocation may not otherwise differ in the matter of danger to life or time of healing from a subcutaneous one, the liability of infection should be recognized and proper precautionary measures be taken to prevent it. An infected dislocation is a serious matter and often requires prompt and efficient drainage of the joint to prevent septic absorption and destruction of the joint surfaces and consequent ankylosis; in the case of the larger joints failure in this is likely to lead to a fatal termination.

When a bone is dislocated at both ends, the dislocation is said to be double, or, by some, total. In the case of those bones which articulate on both sides of the body, such as the lower jaw and vertebræ, dislocation may be unilateral or bilateral, and the latter is sometimes called "total." As there is much ambiguity in the use of the term "total" as applied to dislocations, it may well be dropped.

By habitual dislocation is designated a condition of particular susceptibility of a joint to dislocation brought about most generally by unequal muscular tone or unequal bone development, or by lengthening of the ligaments and capsule, so that comparatively slight force will produce dislocation. Such a condition is allied to pathological dislocation in that stretching of the capsule and ligaments may be the result of effusion into the joint, but it is oftener simply the result of previous luxation of the joint followed by imperfect healing, by which some of the ligaments of the joint may have been lengthened. This is particularly true if the dislocation be once or twice repeated. Habitual luxation is most common in the shoulder because of the shallowness of the glenoid fossa and the unusual dependence of the joint on the tension of ligaments and muscles for stability.

Closely allied also to habitual dislocation and to pathological dislocation is so-called spontaneous dislocation, by which is meant a condition of a joint in which the patient can, voluntarily, by making certain movements, throw the joint out. Like habitual dislocation the spontaneous is more common in the shoulder and is more frequent in early life than in later years. It would seem also to be allied to congenital dislocation, because when present in otherwise sound children it is apt to be the result of defective development, and in certain striking instances has been multiple in the same individual and has been present in several members of a family. During the course of exhausting diseases, especially in childhood—scarlatina, typhoid—the hips and the shoulders are occasionally dislocated with no greater traumatism than that incident to lifting or moving the patient in bed, and the dislocation is clearly the result of atrophy and relaxation of the structures limiting the range of motion of the joint. In many cases spontaneous dislocation is partial, as is shown in many individuals who can by over-extension of the thumb produce a subluxation of the metacarpo-phalangeal joint posteriorly, while others can at will produce a subluxation of the shoulder by simply relaxing the deltoid muscle. Some individuals, especially young girls, whose joints often permit of an extraordinarily wide range of motion, readily hyperextend the elbows and shoulders, in which positions dislocations of these joints are easily produced.

Old dislocation is an expression often applied to a dislocation which can be reduced only with great difficulty, chiefly because of the changes that have taken place in the parts by reason of the length of time that has elapsed since the occurrence of the dislocation. Because of the complexity of the subject, it would seem impracticable to devise a perfectly consistent classification of dislocations. Attempts, for example, satisfactorily to classify dislocations according to the direction and character of the causative forces have proven failures. The conventional classification of Malgaigne, which has been generally adopted, is anatomical. It is based on the static condition presented after the act of dislocation is completed, and is not concerned with the mechanism by which the displacement is brought about. Primarily, of two bones forming a joint, that which has been moved out of its normal relation to the other may properly be said to be the one dislocated. This is not necessarily always the distal, yet is more commonly so. The conventional classification then simply assumes for purposes of description that it is always so; *i.e.*, that the bone which is farthest from the axis of the body is the one said to be dislocated. Thus, one would speak of a dislocation of the upper end of the tibia rather than of the lower end of the femur, independently of whether in a given case the dislocation was produced by movement of the leg on the fixed thigh or of the thigh and body on the fixed leg, as sometimes occurs when, in falling, a man's leg is caught between timbers, and the injury to the joint is produced by the momentum of the rest of the body.

The rule is sometimes enunciated as follows: Of the bones forming a joint, that is said to be dislocated which is farthest from the head when the patient is standing erect with the hands at the side. The objection to this statement is, that it would require the lower of two vertebræ to be designated as the one dislocated, while general usage insists upon the reverse, except in the case of the coccyx. For example, in the relatively common atlanto-axial dislocation the atlas rather than the axis is said to be dislocated. Practically, therefore, the sacrum is taken as the central point rather than the head, and this is after all the more consistent because the support of the spinal column is from the sacrum. Moreover, the vertebræ diminish in size from below upward.

An exception to the rule is presented by dislocation of the acromio-clavicular joint, where usage decrees that the injury shall be described as dislocation of the outer end of the clavicle. Doubtless the reason for this is the fact that the clavicle is so much smaller than the scapula and appears to be the bone moved in the dislocation. However, there is a tendency among surgeons of late to use the term "dislocation of the scapula." Again, dislocation of the distal radio-ulnar joint is generally described as dislocation of the head of the ulna, although the ulna is relatively more fixed than the radius in relation to the framework of the body.

As said above, the term dislocation is applied by preference to the thing which is moved out of place, viz., the bone; and while, by metonymy, one may speak properly enough of the dislocation of a joint, meaning the state of disorganization of a joint consequent on the displacement of one of its constituent bones, that expression fails to describe the condition when several bones enter into the formation of a joint and one or more of them are displaced. In the strife for accuracy some writers speak of dislocation "in a joint," and others go so far as to consider only dislocation "at a joint."

A dislocation may be conveniently described in direction by the simple prefix of forward, backward, upward, downward, inward, or outward, when the term is applied to a bone.

PATHOLOGICAL DISLOCATIONS.

Destructive alterations of joints occur in a variety of diseases both general and local. Of the former, tabes dorsalis and syringomyelia are most prominent, and their local manifestations in the joints, called neuropathic arthritis, frequently lead to spontaneous luxation. Syphilis may also cause destructive inflammation of a joint. Among local diseases leading to disorganization of joints permitting dislocation are tuberculosis, suppurative arthritis, osteomyelitis, arthritis deformans (Fig. 1), and tumors.

Neuropathic arthritis affects by preference the large joints, most frequently the knee and hip in tabes, and the elbow and shoulder about as frequently in syringomyelia. Without going into the pathology and symptomatology of these affections, it may be stated that luxation is permitted by relaxation of the joint capsule and ligaments consequent on the distention of the joint which occurs in the early stages of neuropathic arthritis and is followed by more or less degeneration of the joint. A slight trauma will then produce luxation. Later, the cartilages are eroded and the ends of the bones finally absorbed to so great an extent as to offer no obstruction to the articular ends of the bones slipping past one another. At times this process is accompanied by extensive growth of osteophytes at the edges of the intact periosteum, so that great deformity may exist, with limitation of movement. Neuropathic joints are seldom painful, so that comparatively little distress is caused the patient by the local manifestation of the disease or by the dislocation. Conditions are somewhat different in the knee, where, if the displacement be great, the weight-bearing function is lost. Therapeutically, for the knee, there is little to be done, although in a few cases resection has restored the weight-bearing function. (Hildebrandt.)

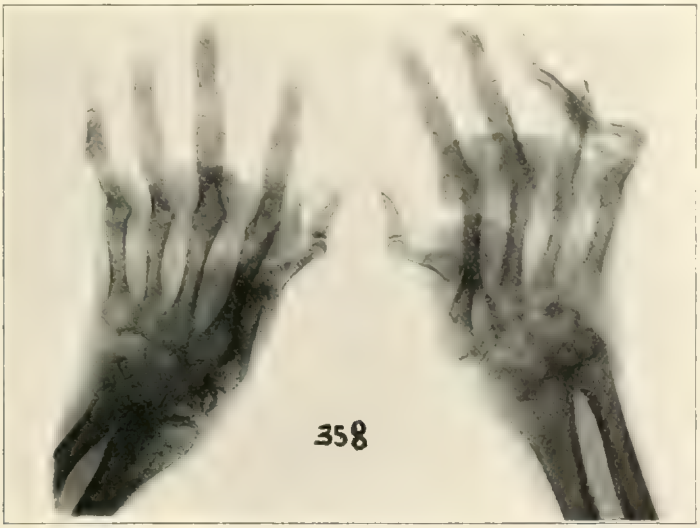

Fig. 1.—Multiple Dislocations of the Carpal Phalanges, the Result of Arthritis Deformans. (Roentgen Department of Lane Hospital, San Francisco.)

Spastic contraction of muscles alone may cause dislocation, as occurred in the hip in a case observed by the writer, the result of a tumor of the dorsal spinal cord. The hip was continuously flexed and adducted when the head of the bone finally was forced out of the acetabulum, downward and backward.

In the secondary stages of syphilis, various joints may be distended with a serous effusion which may so stretch the ligaments as to permit of dislocation, and in tertiary stages destructive processes in the bones may lead to the same deformity.

Tuberculosis causes pathological luxation by its destructive action on ligaments as well as on the articular ends of the bones of a joint. It may affect any joint, but is more common in the hip and knee. In practically every case of extensive tuberculosis of the knee joint there is subluxation of the tibia posteriorly, and, although this seldom progresses to a definite dislocation, it occasionally does so. In the hip the disease may erode away the upper rim of the acetabulum as well as the head of the femur, thereby destroying the structures which limit the upward thrust of the femur, and giving rise to a backward or iliac luxation. The escape of the head of the femur from the acetabulum may take place suddenly, but more often it is a gradual transit. This condition most often calls for resection of the joints affected. The prognosis is much better in young subjects, but the indications for resection or amputation should be sought in the articles on orthopedic surgery and diseases of joints. (See Fig. 2.)

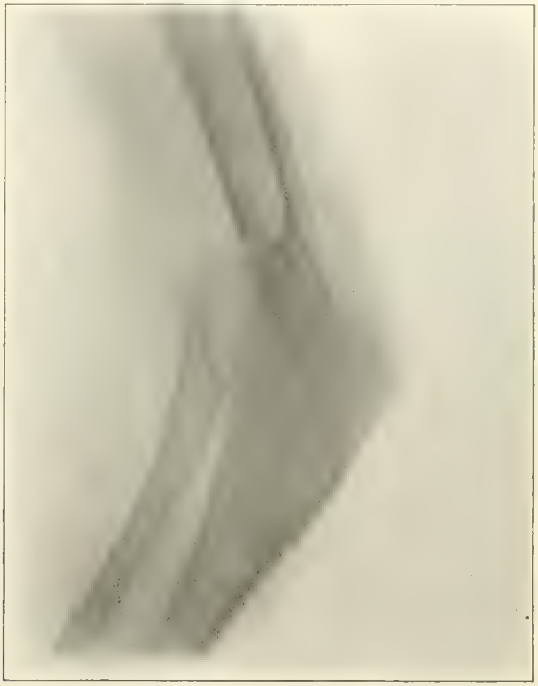

Fig. 2.—Pathological Dislocation of the Head of the Radius Forward, in Tuberculosis of the Elbow. (Roentgen Department of Lane Hospital, San Francisco.)

Suppurative arthritis, *i.e.*, arthritis due to the ordinary pus-producing bacteria, may cause so great an amount of necrosis, particularly in the epiphyses, as to permit of pathological dislocation. (See Fig. 3.)

CONGENITAL DISLOCATIONS.

This part of the subject is discussed further on in the present volume, in the section devoted to orthopedic surgery.

TRAUMATIC LUXATIONS IN GENERAL.

Etiology.—*A priori*, other things being equal, the joint having the greatest range of mobility should be the least frequently dislocated, because of its yielding to forces tending to dislocation, but clinically almost the direct opposite is the fact. The shoulder joint has the widest range of mobility and is the most frequently dislocated of all the joints of the body. Of the joints of the spinal column, which are anatomically similar, the atlanto-axial joint has freest mobility and greatest frequency of dislocation. The reason is that other things are not equal. Joints with the widest range of mobility are thereby of necessity most dependent for their stability, not on the bony parts, but on the tension of soft structures. It happens also that those joints which have greatest mobility are frequently the most exposed to injury and, as in the case of the shoulder, one can only say that, if the mobility were less, dislocation would be still more frequent than it is.

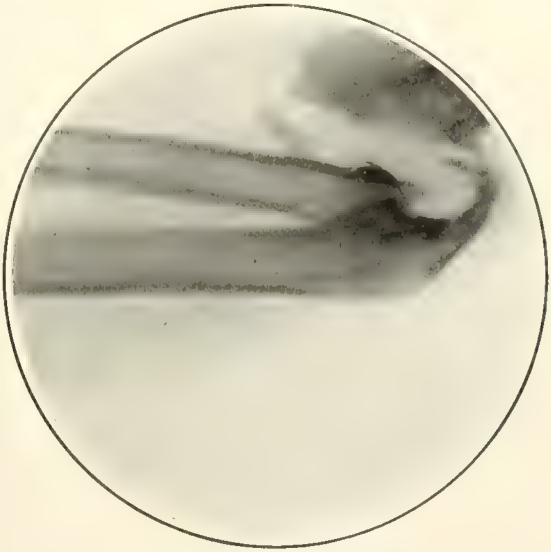

Fig. 3.—Pathological Dislocation of Both Bones of the Forearm Backward in Suppurative Arthritis of the Elbow. (Roentgen Department of Lane Hospital, San Francisco.)

Most true dislocations are produced primarily by "lever action," the bone dislocated being forced beyond the limit of one or other of its normal motions, as in flexion or extension by which the ligaments ordinarily limiting this motion are torn; the resistance of these ligaments being overcome, the causative force is free to lift the articular surfaces apart, acting on the bone as on a lever—the fulcrum in the moment of dislocation usually being the point of contact of the bones on the side of the joint opposite to that of the torn ligaments at a considerable distance from the axis of the normal movement of the joint. Perhaps the simplest example of such lever action is in the common backward dislocation at the elbow, in which at the limit of extension the ligaments on the volar side are put on the stretch and the tip of the olecranon is in contact with the humerus in the olecranon fossa. Continuance of force in the direction of extension lifts the articular surface of the ulna off that of the humerus, the tip of the olecranon being at the fulcrum. But this is not yet a true dislocation. Were there no other element of force active, or if the force were to cease at this point, the bones would fall back into place and the resulting lesion would be a sprain. To produce the posterior dislocation an additional force must be active,—viz., a thrust in the direction of the shaft of the ulna by which the olecranon is forced up on the posterior surface of the humerus, stripping up the periosteum and causing the coronoid process (if not broken off) to slip into the olecranon fossa. Since such a dislocation is most frequently produced by a fall forward on the outstretched hands the longitudinal component may be greater than that producing extension, but, being resisted by the interlocked bones, is not active in producing displacement until hyperextension has lifted the joint surfaces apart by "lever action."

Similarly, in nearly all dislocations the conditions are more or less complicated—there are active a number of forces differing in direction, in intensity and range of activity,—those which are active through means of levers may be of relatively great or small importance according to circumstances.

In dislocations of some of the short bones, *e.g.*, the semilunar bone in the wrist, it is difficult to see how "lever action" plays much, if any, part.

In a much smaller number of dislocations the effective force is a simple thrust, *e.g.*, the humerus is dislocated downward and forward in a considerable proportion of cases by blows on the point of the shoulder. The position of the limb at the moment of application of such a thrust will make dislocation more or less likely.

Akin to direct thrust is transmitted thrust, by which a short bone, being squeezed between two other bones, may be pinched or forced out of place—"cherry-stone" theory of dislocation of the carpal semilunar bone. (Albertin.) By transmitted thrust either end of the clavicle may be dislocated.

The primary positions of bones dislocated are few as compared with the secondary positions which are produced by persistence of action of the causative forces after dislocation has been produced or by the application of new forces as when the position of a dislocated limb is changed by solicitous friends in misdirected efforts at reduction; *e.g.*, in dislocations of the hip the primary position of the head of the femur is most frequently below the acetabulum, but secondarily it is thrown anteriorly or posteriorly, in fact may be forced into almost any position about the acetabulum, separating the capsule from its neighboring structures and occasionally even twisting the capsule around the femoral neck.

Frequency of Dislocations.—The following tables are taken from Stimson's "Fractures and Dislocations," revised fifth edition, 1907, and are reproduced in full.

"Compared with other surgical injuries, dislocations are infrequent; the proportion to fractures is about 1 to 10.

"These tables show the great relative frequency of dislocations of the upper extremity as compared with those of the lower. Each set of statistics shows that dislocation of the shoulder is far more common than that of any other joint, and that next in frequency come dislocations of the elbow. These two dislocations may be estimated as together comprising from two-thirds to three-fourths of all cases, excluding the phalanges.

"As between males and females, Malgaigne and Gurlt found the injury three times as frequent in the former as in the latter; Kroenlein found it five times as great. Dislocations of the lower jaw are an exception, being four times (Kroenlein) as frequent in women as in men.

Dislocations at the Hudson Street Hospital, New York, 1894–1905. Hospital and Dispensary. (Lewis A. Stimson.)

Hip, dorsal	19	Lower extremity, 89—5.82 per cent.
" thyroid	3	
Knee	12	
Semilunar cartilage	13	
Patella, outward	9	
Head of fibula	1	
Ankle	5	
Astragulus	5	
Subastragaloid	5	
Metatarsus and phalanges	17	
Clavicle, outer end	69	Upper extremity, 1,368—89.59 per cent.
" sternal end	12	
Shoulder	617	
Elbow	156	
Head of radius*	18	
Ulna, upper end	13	
" lower end	8	
Carpus	7	
" trapezium	1	
" semilunar	5	
" scaphoid	3	
" os magnum	1	
Metacarpal	80	
Metacarpo-phalangeal and phalangeal	378	
Lower jaw	61	Head and trunk, 70—4.58 per cent.
Vertebræ	6	
Chondro-sternal	1	
Sacro-iliac synchondrosis	2	
	1,527	

*Including cases with associated fracture.

TABLE OF FOUR HUNDRED RECENT TRAUMATIC DISLOCATIONS. HOSPITAL AND POLYCLINIC. (KROENLEIN,* AS GIVEN BY STIMSON IN "FRACTURES AND DISLOCATIONS," FIFTH EDITION, 1907.)

Joints.		Sex.		Age.								Totals.		Percentages of Frequency.	
		M.	F.	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80				
Hip	Iliac	4		2			1		1			4	8	2	Lower extremity, 20 = 5.
	Obturator	2	1	2						1		3			
	Pubic	1							1			1			
Knee	Lateral	4			1	1	1		1			4	7	1.7	
	Patella outward	2	1		2	1						3			
Foot	Backward	1	1				1			1			2	0.5	
Metatarso-phalangeal		3			1				2				3	0.7	
Shoulder	Subcoracoid and axillary	180	23		2	53	44	48	35	19	2	203	207	51.7	Upper extremity, 369 = 92.
	Erecta	3				2	1					3			
	Infraspinous	1							1			1			
Elbow	Of forearm backward	77	17	22	44	14	5	4	3	1	1	94	109	27.2	
	Of radius	9	6	9	5	1						15			
Wrist	Dorsal of ulna	1				1							1	0.2	
Metacarpo-phalangeal		23	4	4	6	8	4	8	1				27	6.7	
Interphalangeal		7	1	1		5	1	1					8	0.2	
Sterno-clavicular		4	2	1	3	2							6	1.5	
Acromio-clavicular		11			1		1	4	3	1			11	2.7	
Lower jaw	Unilateral	2	2		1	1		2				4	10	2.5	Trunk, 11 = 2.8.
	Bilateral		6		1	3	1		1			6		0.2	
Cervical vertebræ		1		1									1		
		336	64	44	69	88	65	60	48	23	3		400		
		400		400											

* Deutsche Chirurgie, Lief. 26, p. 5.

"The following table summarizes the other two with Malgaigne's statistics of the Hôtel-Dieu:

	Cases.	Upper Extremity.	Lower Extremity.	Trunk.
		Per cent.	Per cent.	Per cent.
Malgaigne, hospital	491	85.7	12.6	1.6
Kroenlein, hospital and polyclinic	400	92.2	5.0	2.8
Stimson, hospital and dispensary	1,527	89.59	5.82	4.58

"Age: No age is exempt; dislocations have occurred as early as the moment of birth and as late as the age of ninety years. The relative liability to the injury at different ages is shown, not by simply comparing the number of cases observed at those ages, but by also comparing the numbers of people at those ages living in the community where the observation is made. This comparison has been made by Kroenlein for Berlin, with the following results:

Frequency of Dislocation at Different Ages.

	Age Decades.							
	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
Absolute frequency	44	69	88	65	60	48	23	3
Relative number of people living	1,872	1,620	2,529	1,679	940	599	282	117
Relative frequency as computed for equal number of people	10	18	15	16	27	35	35	10+

"From this it appears that a smaller proportion of individuals between the ages of 1 to 10 and 71 to 80 years receive dislocations than in any other decade of life; and the highest proportions are found between the ages of 51 to 60 and 61 to 70. It is further to be noticed that dislocation of the shoulder is very rare, and that of the elbow very common, before the age of 21 years. Kroenlein's table shows that of 207 cases of the shoulder, in only 2 were the patients less than 21 years old, and that of 109 cases of the elbow 80 were no older, the age in 31 being between 1 and 10 years, and in 49 between 11 and 20 years. Compared with fractures, it appears that the liability to dislocation is least during those periods of life in which the liability to fracture is greatest; that is, in infancy and youth and in old age; the latter part of this statement may need some modification, for while dislocations are rare after the age of 70, they are relatively frequent in the preceding decade. The liability to each increases from adolescence through middle life."

Pathology.—The primary damage done the structures forming and surrounding a joint comprises laceration of the capsule, nearly always with perforation, laceration and stretching (molecular laceration) of other ligamentous structures, tearing them loose from bony attachments, often with laminæ of bone, stripping up of periosteum, lifting off of articular cartilages, etc., any or all of which may be present and to which should be added the lesions of the local complications. The amount of hemorrhage will depend on the size and number of vessels torn. The degree and extent of these lesions determine very largely the symptomatology as well as the prognosis and indications in treatment.

Of the secondary effects muscular spasm deserves first mention, not only because it occurs early after dislocation, but because it so greatly increases the difficulty of reduction. It is partly voluntary, but is also largely involuntary, and is the result of beginning inflammation of the injured tissues. This so-called aseptic or traumatic inflammation ordinarily involves the joint synovial membrane as well as other structures, giving rise to more or less serious disturbance and causing tenderness and pain.

More remote secondary lesions are the end results of this inflammation and the process of repair, which may quite completely be included under the term cicatrization. The results of this process, with contraction of scar tissue, depend largely on the degree of displacement of the injured structures. Bony laminæ may be displaced when, instead of undergoing absorption, they grow. In case of non-reduction of the dislocation these bony masses, together with those formed beneath loosened and displaced periosteum, furnish great obstacles to reduction. Adhesions of misplaced soft parts can be torn even when quite old, but while such new bone can be fractured by manipulation it can seldom be gotten out of the way sufficiently to permit of reduction except by open operation. (Fig. 4.)

Where the dislocation is not reduced, a fibrinous deposit forms on the cartilaginous surfaces within the joint and eventually fills the hollow spaces. This deposit organizes and finally becomes firm fibrous tissue of almost cartilaginous consistence and may eventually become ossified. The formation of a complete synovial sac is reported. It early interferes with complete reduction, but tends to be absorbed when partial reduction is effected and pressure is brought to bear upon it and the joint is systematically moved.

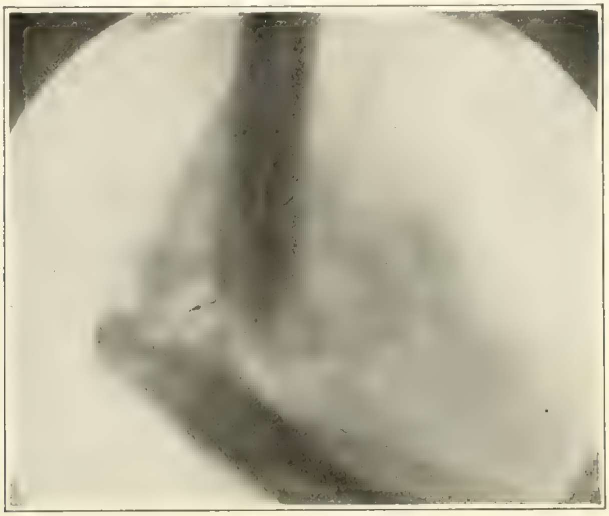

Fig. 4.—Old Unreduced Posterior Dislocation of Both Bones at the Elbow, Showing Newly Formed Bone Beneath the Stripped-up Periosteum. (Roentgen Department of Lane Hospital, San Francisco.)

Complications.—Many of the so-called complications of dislocations are caused by persistence of action of the causative forces after dislocation has been produced, as well as by the application of independent factors, such as rotary or twisting forces. Much depends on the age of the patient; complicating fracture is much more common in adults, while epiphyseal separation occurs in childhood, and stripping up of periosteum is more likely to be extensive in the child than in the adult.

Injuries to the blood-vessels occur more frequently in the aged largely because of the weakening of the walls of the blood-vessels and loss of elasticity by atheroma. They are more common in dislocations of the shoulder than in those of other joints and are favored by adhesions resulting from previous inflammation as well as by fracture complicating dislocation. Serious injury of large blood-vessels is more common as a result of manipulation in attempts at reduction of old dislocations than as a complication of recent dislocations. It naturally increases in frequency with the length of time dislocation has remained unreduced.

Vessels of some size may be torn across, this accident leading to the formation of large hæmatomata which may even pulsate, or a very large number of small vessels may be torn and, in individuals with a tendency to hæmophilia, may cause large hæmatomata. The laceration may be confined to the inner coats, when there may result no other immediate symptom than cessation of the pulse below the point of injury, but, later, aneurism may develop.

Injuries of nerves in the neighborhood of dislocated joints may occur, at the time of dislocation, by crushing, by laceration by fragments of bone, or by stretching, in which case the injury would be said to be primary. In an unreduced dislocation a degree of pressure or stretching too slight to affect the function of a nerve more than temporarily, may, if persistent, lead to serious pressure paralysis. Nerves are less likely to be injured in attempts at reduction of old dislocations than are blood-vessels, but great force of traction will sometimes produce paralysis. As in the dressing of fractures so in the bandaging of dislocations after reduction, pressure paralysis is sometimes produced. The possibility of complications in distant parts of the body should prompt careful general scrutiny at the earliest opportunity.

SYMPTOMATOLOGY.—The general symptoms following dislocation of one of the larger joints, and dependent largely on the degree of violence suffered and of course on the concurrence of other injuries, are those incident to any severe and painful injury; viz., shock, as shown by general weakness with lowering of blood pressure, rapid pulse, pallor, clammy sweat, and often vomiting. These are followed by a period of reaction characterized by mild fever—perhaps from intestinal derangement—with increase in pain.

Immediately after the receipt of a dislocation the joint is loose and the tissues about it flaccid—it can be moved through a considerable range of motion; but very soon, as shock disappears, blood pressure rises, inflammation appears, and puffiness develops into definite swelling, which continues to increase till the whole region about the joint is hard and tense. Muscular spasm comes on, holding the bones in elastic tension, and permitting only a relatively slight degree of mobility. In addition, there are evident deformity (easier to be made out before swelling has occurred), characteristic attitude or position of the limb relative to the rest of the body, limitation of motion, ecchymosis, and sometimes vesication of the skin; crepitus is also often elicited.

DIAGNOSIS.—The most important consideration in the matter of diagnosis is that the examination should be careful and thorough. A rough diagnosis of dislocation scarcely satisfies modern ideas, either as to determination of prognosis or as indicating treatment. Both of these depend too much on the accuracy of determination of complications, and on the extent and degree of damage to the joint structures, as well as the actual size and anatomical position of bony fragments, etc., to justify haste or carelessness in diagnosis.

As a routine measure in all cases the condition of the nerves and blood-vessels passing the joint should be determined, the attitude of the limb in relation to the rest of the body should be observed, and the direction and extent of the motion, the position and degree of the swelling, ecchymosis, etc., should all be carefully noted. Cautious, painstaking palpation may be necessary for the purpose of detecting fracture and in order to locate bony fragments and to ascertain their relations to each other. The relations of bony landmarks should be noted and a record should be made of these and of all preceding diagnostic facts.

No discovery or principle has had such wide influence toward the better understanding of dislocations and toward a rational treatment as that of the Roentgen ray, the importance of which as a means of diagnosis cannot be overestimated. While one would hesitate to say that an *x*-ray picture should be taken of every dislocation, it may safely be predicted that the more often it is done the more often will unsuspected fragments of bone be discovered within the dislocated joint and accurately located. By its aid a record will be made of the exact relative position of the bones and of the presence of complicating fracture, on which data treatment and prognosis largely depend. It should often determine the necessity of primary open operation, the advantages of which over late operation are evident.

While the *x*-ray in the hands of one who would profit by the discomfiture of a confrère who has labored over a dislocation and has failed to secure a satisfactory result without it may lead to a malpractice suit, a good picture taken before treatment is begun will not only cause many an error in diagnosis to be avoided and thereby often cause the unfortunate result to be forestalled, but it will furnish a record which may show that the result was not only to be expected, but was inevitable.

Again, where there is doubt as to the completeness of reduction or as to whether retention has been satisfactory after reduction and after the permanent dressing has been applied, the *x*-ray will often determine the matter, even through non-metallic splints and plaster-of-Paris dressing.

Prognosis.—Reduction of nearly all dislocations is easily effected, and without a general anæsthetic, during the period of primary shock before muscular spasm has set in, but the difficulties of reduction increase in nearly direct ratio to the time which has elapsed thereafter. The earliest hindrance to reduction is muscular spasm, which in powerful individuals, especially if they are under the influence of alcohol, may require the use of great force or else a general anæsthetic. In individual joints special anatomical conditions interfering with reduction occur and will be discussed in connection with the joints involved.

If reduction is effected, the final functional result is dependent, among other things, on the duration of the dislocation before reduction (amount of new bone thrown out, inflammatory exudates, etc.); and the influence of time in bringing about absorption of such exudates is most important. In other words, even if reduction be effected after enough fibrous tissue or even bone has formed to interfere with motion of the joint, it is permissible, in the absence of serious inflammation, osteo-arthritis, and the like, to expect that more or less absorption will take place in time and with movement of the joint, so that after six months or a year the function will in nearly all such cases be far better than at the end of the first month.

If reduction is not effected the final result will depend on the amount of damage done by the original injury or by efforts at reduction, on the amount of new bone and inflammatory deposits, on the degree of displacement of lacerated structures, and on the amount of cicatricial contraction. These conditions will cause ankylosis or at best great limitation of motion, persistent tenderness, loss of power, and deformity, although even in this case absorption in time will give some improvement in function.

In a few individual dislocations, such as the dislocation of the humerus, forward, a new joint will sometimes form in time, permitting considerable degree of useful motion, and in anterior luxation of the hip the weight-bearing function may be preserved.

Treatment.—Partial dislocations are often spontaneously reduced when by any means tension of the muscles controlling the joint is relaxed. Otherwise the simplest manipulation will generally suffice unless there be present some complication preventing.

Complete dislocations may often be reduced during the depression and shock which follow immediately on the receipt of the injury, and not infrequently reduction is made at this time by friends who pull on the dislocated limb; whereas in similar cases, after shock has been overcome and muscular spasm has set in, the difficulties of reduction may be great.

So much depends on the tension of the muscles that the reduction of a dislocation, which in an individual of feeble muscular power may be effected without difficulty, may be all but impossible in one powerfully muscled, especially if the patient be under the influence of alcohol. In such a case a general anæsthetic should be given as a primary matter, rather than to use it after strenuous efforts at reduction have failed. In many cases of recent luxations nitrous-oxide anæsthesia will be sufficient, but, if the case is found to be a stubborn one, full ether or chloroform anæsthesia should be induced.

In general, with the muscles entirely relaxed, complete dislocations can be reduced with the use of but little force if by manipulation the rent in the capsule is found. I refer particularly to the hip and shoulder, where, if the rent be not found, great difficulty will be encountered. It is important to remember that a rent in the capsule may change its form greatly with change of position of the limb, particularly in rotation, even to the extent of a spacious rhomboid being reduced to a mere slit between parallel sides, and this may determine the difference between reducibility and irreducibility. Care should therefore be taken to reproduce as nearly as possible the position of the limb at the moment of dislocation. The head of the bone dislocated should be led back along the course it took in the whole process of dislocation. In any event the preliminary efforts at reduction should be directed to relaxation of muscles by anæsthesia and by position of the limb and to searching with great gentleness for the rent in the capsule. With these two principles in view, the great majority of dislocations can be reduced if taken early and if no hindering complication, such as a fragment of bone lying in the joint, is present. As said above, the *x*-ray is invaluable in the latter event and should be most useful in preventing the futile use of force.

The use of great force is never justified in the reduction of refractory dislocations provided the surgeon has proper knowledge and facilities for performing an open operation, since the danger of operation is often small as compared with that of injuring vessels and nerves and causing serious fracture where great force is used. The day of tackles, purchases, and screws in the reduction of dislocations is definitely past.

In the after-treatment of dislocations the torn parts should be put at rest till the rent in the capsule has healed and the inflammation in the joint and surrounding tissues has had time to subside. For the major dislocations this would amount to from two to three weeks; but, in cases with much tearing of joint structures or with serious complications, a longer fixation is advisable in order to avoid the tendency to recurrence which follows imperfect healing. When retentive bandages are removed, massage and gentle active and passive movements should be employed, special care being taken not to move the joint more than a fraction of its normal range at first, and only gradually to increase the range of such active and passive movement.

DISLOCATION OF INDIVIDUAL JOINTS.

Dislocations of the Vertebræ.—Dislocation of the vertebræ is not common and at one time was supposed not to be possible except as a complication of fracture. However, it is now established that diastasis and dislocation as well do occur, both with and without complicating fracture. It is important to distinguish between those cases in which displacement is the result of fracture and those in which the fracture is an insignificant complication of dislocation, but clinically such differentiation may be very difficult.

By diastasis is understood separation of the body of one vertebra from that of its neighbor next below, without much horizontal displacement (Koenig), involving laceration of the intervertebral disk and the connecting ligaments or at least separation of the vertebral bodies from each other in front or behind, the articular surfaces remaining practically in line with each other. It may occur as the result of excessive extension (dorsal flexion), the point of contact of the vertebræ posteriorly being the fulcrum about which the excessive rotation or extension occurs. This point is in the first instance the point of contact of the apices of the articular processes with the laminæ, but further extension may bring the laminæ themselves or the spinous processes into contact, and thereby change the position of the fulcrum farther back. Under these circumstances fracture of one or more of the articular processes, spinous processes, or laminæ is very likely to take place.

Dislocation of a vertebra may be forward or backward, and either may be partial or complete; the complete is seldom simple, but is apt to be complicated by fracture of an articular process or by laceration or separation of the intervertebral disk and various ligaments.

Dislocation forward may be bilateral (double) or unilateral; in the former case it is the result of excessive flexion, by which the articular processes of the upper of two vertebræ are slipped upward over the apices of their articulating processes from the vertebra next below and lodge in front of them. There is of necessity more or less anterior displacement with laceration of the syndesmosis and of the other ligaments of the arch. The capsules of the joints between the articular processes are so loose and extensive that the displacement must be great before they are ruptured.

Unilateral dislocation is the result of lateral or oblique flexion (rotation) in which the articular processes on the side of the concavity (sound side) are slipped on each other, the apex of each toward the base of the other, until arrested by bony contact. This point furnishes a fulcrum, and further lateral flexion exaggerates the slipping apart of the articular processes of the side of the convexity (unsound side) until the apex of the upper passes in front of that of the lower vertebra and there lodges. Because of the fact that the axes for the physiological lateral flexion movement between the pairs of vertebræ are not precisely horizontal but are inclined in varying degrees forward (in the upper part of the neck one or two of the axes are nearly vertical), there is always present a certain amount of axial rotation of the body of the upper of two vertebræ to the side of the concavity. This rotation in the process of dislocation produces an oblique shearing strain in the syndesmosis and tends to prevent bony contact of the edges of the bodies on the side of the concavity. Added external force of rotation in the same direction will then markedly increase the tendency to dislocation, from which fact unilateral dislocation is often called dislocation by rotation. Backward dislocation of the joint on the side of the concavity is then not unthinkable (Koenig), but the tendency thereto is powerfully resisted by tension of the ligaments of the articular processes, the tension of the lateral ligaments between the vertebral bodies, and even if it does occur there is no bony resistance to reduction of the displacement. The lesion might more properly be classed as a sprain.

In such unilateral dislocation, sometimes called dislocation by abduction, there is present as one of the signs of dislocation a considerable degree of axial rotation, the body of the vertebra being displaced to the side opposite to that of the dislocation.

Dislocation is most frequent in the cervical region and least frequent in the lumbar. In the former the bodies of the vertebræ are smaller and are more nearly cylindrical and the articular processes more nearly horizontal, by reason of which facts a much greater degree of mobility, not only of axial rotation, but also of flexion in various directions, is permitted. In the dorsal region, although the vertebral bodies are not large, all movements are greatly hindered by the ribs and the manner of their attachments, and in the lumbar region the bodies of the vertebræ are very large, especially transversely, by reason of which all movements are restricted, but especially lateral flexion. Furthermore, their articular processes are strong and stand nearly vertically, permitting of relatively slight degrees of axial rotation. In fact, in the lower lumbar region the axes of joints between the articular processes are almost vertical, by reason of which arrangement scarcely any other motion is permitted than slight vertical displacement in flexion and extension of the lumbar spine.

SYMPTOMS.—In the general case the symptoms and signs of dislocation of the spine are the following: suggillation; muscular spasm; rigidity of the spine; pain from compression or injury to the spinal nerves at their points of exit, as well as pressure paralysis (mostly unilateral lesions); symptoms on the part of the spinal cord which may be damaged by longitudinal traction or by transverse compression (the upper edge of the body of the vertebra below the dislocation and the lower edge of the laminæ of the upper vertebra); laceration of the dura and of the vessels of the spinal canal, causing hæmatoma; and signs due to the displacement—viz., anterior displacement of the vertebral body (in the neck this can often be felt through the pharynx), sharp flexion of the spine at the point of dislocation, and, in the case of rotation (unilateral dislocation), a rotary deformity of the spine to the side opposite to that of the dislocation.

The peculiar forms of the occipito-atlantal and the atlanto-axial articulations have much to do with the relative frequency of dislocations of these joints and the general characters of the same. The occipito-atlantal articulation resembles a ball-and-socket joint because of the fact that the articular surfaces are nearly spherical, the lateral diameter being shorter than the antero-posterior.

The concave surfaces of the atlas are sometimes called the glenoid cavities of the atlas. The joint permits of motions in all directions, but more widely in antero-posterior and in lateral flexion; the axis for the former passing through the mastoid processes and that for the latter passing somewhat above. While the antero-posterior axes of the lower vertebræ incline forward in varying degrees, the axis in lateral flexion, on the contrary, inclines backward, *i.e.*, it is nearly parallel to the basilar process of the occipital bone, from which it follows that in the motion of lateral flexion of the head the vertex and the chin move in opposite directions, *i.e.*, the chin rotates to the opposite side.

The atlanto-axial joint permits of axial rotation only and to about thirty degrees in each direction (right and left).

The movements of the atlanto-axial articulation are determined chiefly by the odontoid process of the axis, which lies in a sort of ring made up of the anterior arch of the atlas and the transverse ligament. This ligament is of great strength and is firmly attached to the atlas, and besides sends a process downward to the body of the axis and another upward to the occiput. The odontoid is prevented from slipping out of this ring chiefly by two lateral check ligaments passing from its apex to the occiput (ligamenta alaria), and a central vertical bundle passing directly upward to the anterior edge of the foramen magnum and called the suspensory ligament of the odontoid. Another firm broad ligament—the middle occipito-axial ligament—passes upward from the posterior surface of the body of the axis to the occiput, in company with the common intervertebral ligament, which also passes upward to the occiput in front of the spinal cord. To these should be added the ligaments in front of the spinal column and behind, as well as those between the transverse processes.

It is interesting to note that the axial rotation of the atlanto-axial joint is accompanied by a simultaneous depression of the atlas, due to the peculiar form of the articular surfaces of the axis, and by means of this the shortening of the vertical ligaments mentioned, especially the broader ones, due to the twisting, is compensated. (Testut.)

Dislocation of the occiput (often called dislocation of the head) is exceedingly rare—Blasius could find but two authentic cases, those of Boisson and Coste, both of which were posterior dislocations, complete only on one side and incomplete on the other. In Coste's case the atlas was thrown bodily forward by a blow on the back of the neck, causing in addition an anterior dislocation of the atlas, with fracture of the odontoid process. (Koenig.) Doubtless the reasons for the extraordinary rarity of this dislocation are: the depth of the joint; the fact that it is protected by the overhanging occiput and is supplied with many and very strong ligaments and controlled by many strong muscles; but, more important still, the protection afforded by the readiness with which excessive strain in the occipito-atlantoid joint is taken up by the atlanto-axial joint and the joints of the lower cervical vertebræ.

In dislocation backward the head is flexed forward and laterally to the side opposite to that of the dislocation.

Dislocation of the atlanto-axial joint is much more common. It occurs more frequently in children, perhaps because of the relatively large head and certainly very largely because of the relatively undeveloped odontoid process. It may be a simple diastasis, which is sometimes associated with fracture of the odontoid (characterized by anterior flexion) and which merges into anterior dislocation proper (*inclinaison* of Malgaigne).

Dislocation of the atlas may be unilateral or bilateral, complete or partial, forward or backward. (Figs. 5 and 6.) Because of the large size of the articular processes, if the dislocation is complete on one side there is at least a partial dislocation on the other, and generally in the same direction.

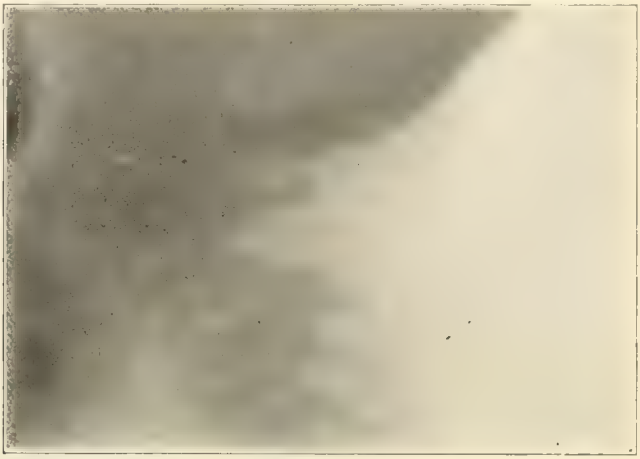

Fig. 5.—Unilateral Anterior Dislocation of Atlas in a Boy of Twelve Years, Showing Wide Angle between Laminæ of Axis and Atlas. (Roentgen Department of Lane Hospital, San Francisco.)

These dislocations are produced by indirect violence (very exceptionally by direct), by a fall or a heavy blow on the head, producing sudden and excessive flexion or extension, especially if combined with forward or backward thrust. The sudden lifting of a child by the head, etc., has been known to result in a rotary dislocation. In all of them the spinal cord is in the gravest danger. In complete bilateral dislocation forward, either the odontoid process is fractured or the transverse ligament is torn. Fracture of the odontoid is a favorable circumstance because thereby the cord may escape, *i.e.*, if the horizontal displacement is not excessive; but, if not fractured, the odontoid crushes through the cord, producing immediate death from cessation of respiration. Minor degrees of injury to the cord may result in more or less extensive paraplegia.

In complete dislocations backward the odontoid is of necessity fractured, the anterior arch of the atlas being structurally more compact, and, as it receives in this case only direct force, it is much less likely to give way than the odontoid because of the development of a considerable leverage or bending movement in the latter. In this case the damage to the cord will depend on the degree of displacement backward.

In partial dislocations or in those which are unilateral, where the articular process of the atlas passes anteriorly to that of the axis and lodges in front of it, there is generally fracture of the odontoid, without which the cord would often be crushed.

Unilateral dislocation forward is by far the more common of these dislocations and may be complete or partial, *i.e.*, the articular process of the atlas on that side is thrust forward and in case of complete dislocation its posterior edge is hooked in front of the anterior edge of its fellow on the axis; there is present then a rotary displacement to the opposite side, with marked flexion of the head, so that the chin rests on the chest, and in addition the head is inclined laterally to the same side (abducted) and is held rigidly in this position by muscular spasm. The projecting atlas can be felt in the pharynx and a corresponding depression beneath the occiput, with unusual prominence of the spinous process of the axis.

Dislocation of the atlas by simple axial rotation may occur, and while the odontoid is not apt to be broken, the medulla is still endangered because when the ligaments are torn the medulla follows excentrically the movement of the atlas and may be compressed laterally.

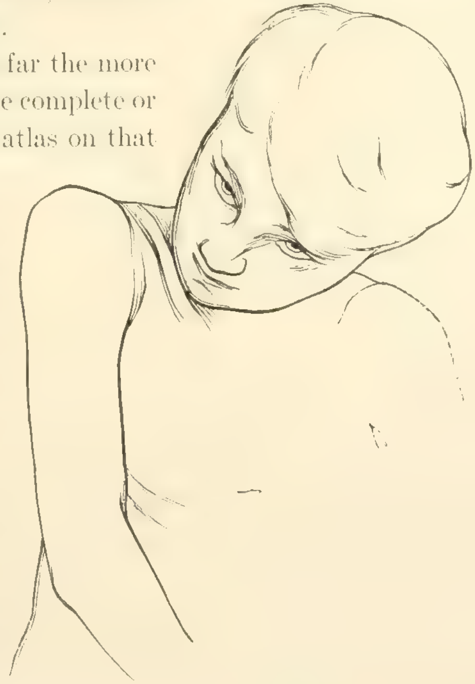

Fig. 6.—Attitude Maintained by the Patient whose Condition is Pictured in Fig. 5. (Original.)

In any dislocation of the atlas death may ensue at the very beginning from crushing of the medulla, or it may occur later, even after a week or more, as the result of slipping of the bones or fragments at that time.

The *x*-ray is of some considerable value in the diagnosis of dislocation of the cervical vertebræ, for in this region it is possible to take a lateral radiograph by which not only will antero-posterior displacement be shown, but, in the case of dislocation of the atlas, there will be shown the very marked rotary displacement forward; lines passed through the arches of the atlas and the axis should be parallel—in dislocation forward these lines make an angle of ten to thirty degrees (James A. Kelly, in *Annals of Surgery*, Vol. XLII., 1905). (See Fig. 6.)

Of the remaining cervical vertebræ the fourth, fifth, and sixth are most frequently dislocated, and generally forward. Especially is this true of the fifth. Dislocation here partakes of the general characteristics of dislocation of the vertebræ.

Dislocation by flexion is forward, and the head and neck, besides being flexed, appear to be driven forward, and, according to the degree of displacement of the articular processes, the head may be inclined either to the same side as the dislocation or to the opposite side, and whatever rotation is present is always to the opposite side.

Dislocation by rotation may be forward on one side or backward on the other, or both, which will give a corresponding variation in the position of the head.

Treatment.—Treatment of cases of dislocation of the cervical vertebræ should be directed to reduction of the dislocation and subsequent fixation. An anæsthetic should be given, and, to prevent a sudden movement of the head when the muscles relax, the head should be held by the operator while the anæsthetic is being given. Often, when relaxation comes on, diastases and partial dislocations reduce themselves spontaneously. The special treatment relates to the reduction of the dislocation, the maintenance in position, and the employment of measures intended to lessen or cure the effects of the injury. If reduction is impossible then operative practice or some discreet non-operative method should be utilized. If reduction is advisable it should be promptly attempted, although it may be successful after the lapse of a week and possibly even as late as after a month or two have elapsed. Before any attempt at reduction is made, especially in the cervical region, the patient or friends should understand that not only may the effort fail, but that pressure on the cord may be caused or be increased, and even that sudden death may attend the efforts at reduction. The possibility of failure, and of grave disaster from the manipulative efforts, should incite the surgeon to a most careful consideration of the diagnosis, especially in its relations to the manner of causation, the seat and direction of the deformity, and the consequent method of procedure. In urgent instances the promptest activity is demanded, the chief reliance being placed on traction, supplemented with suitable flexion, rotation, and pressure of the spine. If reduction cannot be accomplished, and if operative practice be not advisable, immobilization is required, so that suitable repair of the parts in their new relation may be secured. It is often surprising how good are the results which may thus be obtained.

In dislocation of the occiput, steady, firm traction on the head, attended with direct pressure and forward or backward movements of the head, as the case may be, in complete dislocation, and with extension and rotation of the head toward the dislocated side in unilateral displacement, affords an efficient and easily available means of restoration. (Fig. 7.)

In dislocation of the atlas the relations of the parts concerned are of such a nature that the employment of manipulations should be resorted to with very great caution. And in this connection the fact should be mentioned that several patients with presumptive dislocations at this situation have survived in fair condition persistent displacements. Some, however, have succumbed to the efforts at reduction.

In bilateral dislocation steady, firm traction in the line of the axis of the upper segment (backward and upward) should be made, the lower segment (the neck) being, so far as possible, held immovable by the hands. Any local manipulations or rotative movements should be made continuously and with a clear conception of the dangers which they invite.

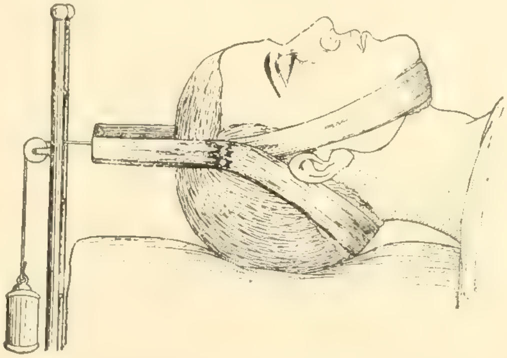
FIG. 7.—Continuous Extension of the Cervical Vertebræ. (After Lejars.)

If the dislocation be unilateral the head is rotated to the sound side while the extension is being made, and subsequently restored to the normal position.

In dislocation of any of the lower six cervical vertebræ the form of manipulation will depend on the variety of the displacement. (Fig. 8.) In the case of subluxation, increase of the lateral flexion, followed by slight rotation toward the dislocated side with lessening of abduction, will effect restoration in many instances. A failure of an attempt should be followed by a repetition with somewhat increased force.

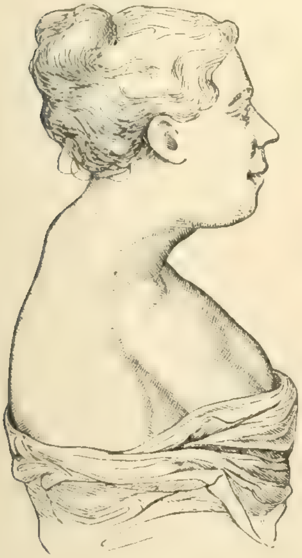
FIG. 8.—Bilateral Luxation of the Fifth Cervical Vertebra, Five Months Old. (After Blasius.)

In instances of complete unilateral dislocation Kocher stretches the ligaments of the unsound side by increasing the lateral deflection, while at the same time he employs slow traction and rotation toward the affected joint. Rotation toward the sound side disengages the articular processes of the opposing side, when abduction to the sound side with rotation toward the unsound carries the displaced articular process into proper position. In bilateral complete dislocations, first one side is reduced and then the other, according to the manner just described. It is well to remember that rotation of the spine above the seat of injury should be made by grasping the upper segment, and not by turning of the head; the latter manœuvre, being used for the purposes of traction and counter-extension, is attained by command of the shoulders. After reduction of the dislocation, the head should be supported and fixed in position by some suitable apparatus maintaining occipito-mental traction, or a high plaster-of-Paris yoke and collar should be applied and worn for about three weeks. (Fig. 9.)

Even with satisfactory mechanical treatment these dislocations are apt to heal with some slight displacement of a fractured process or with union in slight malposition of a torn ligament, with some consequent limitation of movement. As already mentioned, dislocations in the dorsal region are favored by some and hindered by other anatomical arrangements. The surfaces of the articular processes are quite vertical, an arrangement which is not greatly opposed to dislocation by rotation or flexion, especially in the presence of fracture. On the other hand, the intimate and strong association between the ribs and sternum and the spine affords much protection from this injury. While the relations of the articular processes between the twelfth dorsal and first lumbar vertebræ seem not to favor dislocation so much as do those above, yet the freedom of motion and the greater demands on this part of the spine make it the most common seat of fracture of the dorsal or the lumbar region. More than half of the dorsal fractures occur at this situation.

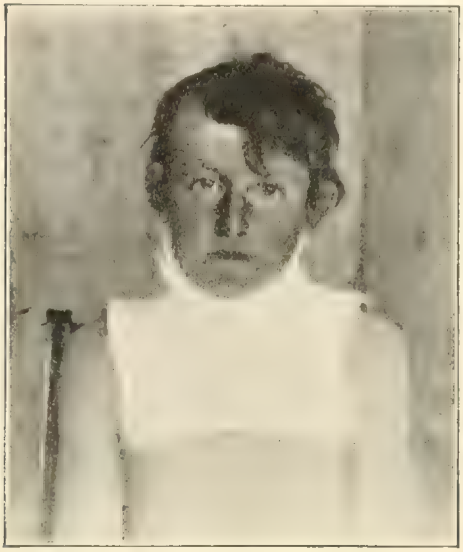

FIG. 9.—Plaster-of-Paris Collar used in the Case Pictured in Figs. 5 and 6. The final result was a perfect poise of the head and nearly complete mobility. (Original.)

According to Stimson "bilateral forward and backward dislocations" occur with about equal frequency. The "bilateral in opposite directions and the lateral" also happen. The degree of the primary injury and the extent of the displacement control the degree of damage done to the cord. The common causes of dislocation are forcible flexion of the spine and direct violence, especially due to moving vehicles and other heavy objects. The symptoms are related to the loss of power and deformity. The former may be due to the injury alone or to complications of the spinal cord, which will be disclosed by careful examination. Prominent bony points may be noted and even movable fragments detected when fracture is present. If the abdominal walls be thin, inequality in outline of the bodies of the vertebræ may be determined. In fact, the symptoms of dislocation and fracture are so nearly alike that diagnosis of either without operation or autopsy is uncertain, and it is largely this uncertainty which has led to the use of the expression "fracture-dislocation." Non-operative treatment begins and ceases with the advantages gained from extension and counter-extension, supplemented with manipulation addressed anteriorly to adjustment of the bodies of the vertebræ when practicable.

Recumbent posture, with immobilization by plaster-of-Paris or other suitable material, and attention to the functions and to cleanliness of the body are also enjoined.

Dislocation of a lumbar vertebra is rare. The great strength and the mechanism of the parts concerned almost forbid the occurrence of an injury to these parts. But three or four cases have thus far been recorded. In these great force caused serious injuries of the vertebræ with more or less displacement of the bodies of the bones. The symptoms distinctive of injury of the cauda equina are not well defined; they indicate more or less circumscribed involvements of parts and are not of that general nature which characterizes injury of the cord. Local deformity and tenderness and even bony irregularities of the processes and bodies of the vertebræ may be made out by careful examination, as in the preceding instance.

Backward dislocation may be reduced by direct pressure on the spinous process, with extension and counter-extension of the spine. In forward dislocation extension and counter-extension, with pressure in front, might be effective, especially in thin people.

Dislocations of the Pelvis.—Since the sacrum and the ilia joined by their synchondroses form integral parts of the pelvic ring, it is customary to regard diastases of these half-joints as more nearly allied to fractures than to dislocations and to describe them under the head of fractures. They are severe injuries, the result of great violence applied generally on one side of the pelvis, as in falling from a great height and alighting on one leg, or on one ischium, or by falling astride of some object which would spread the ossa innominata apart, or, in riding a bucking horse, by being thrown upon the withers. Compression violence, as when the pelvis is caught between opposing forces, is a not infrequent cause. Cases have also been reported as occurring in childbirth.

Malgaigne described the possible disastases as of the symphysis pubis, of one sacro-iliac synchondrosis, of both synchondroses, of one synchondrosis and the symphysis pubis, and of all three articulations together.

In diastasis of the symphysis pubis there is abnormal mobility vertically as well as horizontally, which interferes with locomotion and which brings unusual strain on the sacro-iliac synchondroses. If the displacement is great the sacro-iliac joint on one side or the other is necessarily spread apart and the whole os innominatum is loosened. The triangular ligament is apt to tear apart the membranous urethra, and there have been described cases where the prostate has been damaged and even the bladder ruptured or the iliac vein or artery torn across.

In diastasis of the sacro-iliac synchondrosis the displacement is outward and backward because of the obliquity of the plane of the joint. The abnormal mobility brings severe strain on the ligamentous apparatus in locomotion, causing such great pain as often completely to prevent the patient from walking. For this condition Christopher Heath of London devised a stout pelvic belt by which the joint surfaces are more or less pressed together and fixed, and which is of great value in making locomotion possible.

It should be remembered that the sacro-iliac joint has a small pseudo-synovial sac, as has the symphysis pubis, and permits a certain degree of movement of a rotary character (from five to ten degrees) about a transverse axis passing along the posterior surface of the sacrum at the level of the junction of the first and second segments of the sacrum (Testut)—a motion which materially assists in childbirth, increasing the antero-posterior diameter of the pelvic outlet, and which otherwise is produced by the person bending sharply forward or backward at the hips.

A notable case is reported by Wilhelm (*Gaz. des Hôpitaux*, 1899) in which, as the result of direct violence on the sacrum posteriorly, this bone was driven bodily forward. The patient was able to walk after four weeks, but with a gait resembling that of double hip dislocation.

Sprain and partial dislocations of the sacro-iliac synchondrosis are considered by Goldthwait and Osgood, of Boston, as often produced by indirect force or by muscular action, especially in twisting of the trunk while lifting heavy weights, perhaps with the weight being borne more on one leg than the other, and as the real lesion present in many cases of so-called "lame back." As an evidence of the presence of such sprain or partial dislocation they point to the fact that there is in such cases pain on forced flexion of the thigh when the leg is extended and not when the leg is flexed, as well as tenderness elicited by pressure over the joint, and they report a number of cases in which certain manipulations, generally under an anæsthetic, have brought forth a bony click in the neighborhood of the sacro-iliac joint, followed by immediate cessation of the disability and complete relief, save for soreness, which might be expected to persist. After reduction as thus effected, they advise fixation of the parts of the pelvis by firm application of straps of adhesive plaster.

Dislocations of the coccyx—often spoken of as the only true dislocations of the pelvis—are not common, but have been described as anterior (forward), posterior (backward), and lateral (one case), the result of direct violence as in falls in a sitting posture. The lesion is singularly painful, probably because of the nerves, which richly supply this region, passing through rigid fibrous structures and being thereby injured. In other cases there is left a chronic inflammation of the sacro-coccygeal joint (coccygodynia) set up by the traumatism, in which case there is no satisfactory treatment except excision of the coccyx, and even this may be futile.

Dislocations of the Ribs.—The ribs, while encompassing the thoracic contents, maintain the relation of the sternum to the spinal column and at the same time are articulated so as to permit of considerable movement of the sternum and change of volume of the thoracic cavity in respiration. To the vertebræ the ribs are attached each by two joints, one on the body of a vertebra and intervertebral disc and the other on the transverse process. The last two ribs lack the second-named joints, although strong ligaments are here present. The first, tenth, eleventh, and twelfth receive the entire heads of the corresponding ribs. To the sternum the first seven ribs are united through their costal cartilages by means of synchondroses or half-joints with double facets. The eighth, ninth, and tenth do not reach the sternum, but are articulated one to another, and the eighth to the seventh by two similar joints.

Dislocations in these synchondroses occur, though rarely, and for the most part on the application of direct violence, and are often inconsequential complications of serious fractures of the ribs. According to Stimson (1905) there have been reported but 9 costo-vertebral dislocations, 8 chondro-costal, 14 chondro-sternal, and still fewer chondro-chondral dislocations.

In the costo-vertebral articulations dislocation occurs only in the forward direction. The rib end may enter the pleura or may tear the accompanying intercostal artery, causing severe hemorrhage into the pleura. (Hoffa.)

The diagnosis is apt to be obscured by the thick muscles of the back and the results of the local traumatism which is nearly always present. It may not be possible to exclude fracture. Diagnosis is, however, to be made on the sharply painful condition following a severe injury to the chest wall, the abnormal mobility of the rib posteriorly, the palpable depression over it, and the absence of bony crepitus.

Dislocation or diastasis of the costo-sternal joints is shown by prominence of the sternal end of the cartilage in front of the sternum and its bulging forward when pressure is made on the more prominent ribs some distance away. In the case of the joints between the seventh, eighth, ninth, and tenth costal cartilages, indirect violence, muscle traction, as in lifting heavy weights or bending sharply backward, one of the cartilages may be loosened from and slip upward and behind the next cartilage above it.

By pressing the more prominent cartilage upward the one dislocated may be made to slip out into place. For the most part replacement and retention as ordinarily effected are only incomplete, and, although the region may be acutely painful for a time, no permanent distress is apt to follow.

Dislocation of the Lower Jaw.—The temporo-maxillary joint is the only joint in the body furnished with a capsule large enough to permit of luxation without rupture. (Hoffa.) It is divided into two cavities by a meniscus of fibrocartilage which partakes of the forward and backward movement of the mandibular condyle. The combined motions of condyle and meniscus are equivalent to a rotation about a horizontal axis at about the site of the internal maxillary foramen, an arrangement beautifully calculated to prevent injury to the nerve in the continual movement of the jaw.

When the jaw is forcibly opened beyond a certain point, the meniscus is lifted forward over the articular eminence, and luxation results. Because of the fact that this tubercle is not fully developed till adult life is approached, luxation of the jaw rarely occurs in childhood. Luxation outward or inward may accompany fracture of the jaw, particularly of the ascending ramus, but does not occur otherwise. Luxation backward is possible in some individuals (adult women, Thiem) because of the development of a vertical process behind the joint and in front of the auditory meatus over which the condyle of the jaw may be caught. Otherwise a retention of a posterior displacement could take place only after fracture of the anterior wall of the bony auditory meatus.

The typical luxation forward may be unilateral or bilateral and may be produced by such muscular actions as gaping, shouting, striving to take a too large mouthful, etc., also by external force applied to the chin for the purpose of opening the mouth forcibly.

When dislocated the jaw may be moved through a small angle, but cannot be closed. Efforts of the patient to close the mouth merely cause the condyles to penetrate deeper into the temporal fossa. The principal obstruction which prevents spontaneous reduction and which holds the bone in elastic tension is the external lateral ligament, which, instead of extending obliquely downward and backward in luxation, extends obliquely downward and forward,—the condyle having passed anteriorly to it. (Fig. 10.)

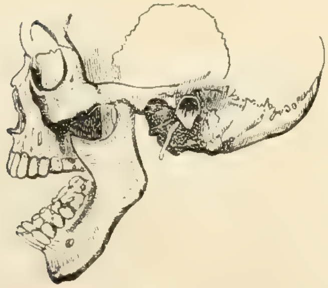
FIG. 10.—Dislocation of the Lower Jaw Forward. (After Tillmanns.)

The position of the jaw is characteristic: in double luxation the mouth is widely open, in unilateral the jaw is deflected toward the sound side. In fracture of the auditory meatus with posterior displacement of the condyle the jaw is deflected to the side of the injury. With the mouth in the characteristic condition in luxation, the patient cannot pronounce certain consonants, cannot chew his food nor close his lips, for which reason he cannot retain his saliva. There are a palpable depression at the normal site of the condyle and an elevation in front, both of which may be visible in thin individuals.

If the luxation is not reduced the deformity gradually becomes less, so that in time the back teeth may come into contact and the patient be able to close his lips, but the deformity is never entirely overcome. The condition may be painful from pressure on filaments of the fifth nerve, but often is but little painful.

After dislocation has once occurred, it is apt to recur and may become habitual, so that the individual must be constantly on guard to avoid gaping or otherwise opening the mouth too widely.

Treatment.—In recent cases reduction can generally be effected very easily, —it is often accomplished by the patient himself,—but, on the other hand, in a short time, because of inflammation and muscular spasm, reduction may become exceedingly difficult.

The following manipulation is successful in most cases: the patient sits upright, his head steadied by an assistant behind while the operator stands in front. The operator's thumbs, wrapped with gauze, are placed on the molar teeth on either side, the fingers of each hand grasping the body of the jaw. By pressing downward and backward strongly, the operator is generally able to carry the condyle over the articular tubercle, and as his thumbs slide outward into the cheeks the teeth come together. In some cases it is found advantageous to make backward pressure on the coronoid process. In other cases spasmodically contracted muscles require to be stretched and ligaments relaxed by opening the mouth widely, and the above manipulation is then carried out with the jaw in that position. In the manipulation, the lower jaw is used somewhat as a lever, the operator's thumbs being the fulcrum.

Sometimes in double luxation success is reached by attacking first one side and then the other. If reduction is not effected, resort may be had to section of the external lateral ligament. Section of the coronoid process has been shown to be of no advantage.

In an occasional refractory case a general anæsthetic may be required.

In older cases an anæsthetic should be given and adhesions carefully broken before the manipulation is attempted. If it then fails, arthrotomy should be performed with section of the obstructing bands; and, if reduction is not then possible, resort may be had to resection of the condyle, an operation the results of which are generally very satisfactory.

After reduction is accomplished the jaw should be kept at rest by being bandaged firmly to the upper jaw for about a week, the patient being fed on liquids. He should be cautioned against opening his mouth widely for a considerable length of time lest dislocation recur and become habitual.

For habitual luxation of the jaw it has been proposed (Genzmer) to inject iodine into the capsule to produce constriction.

Dislocations of the Clavicle.—(*a*) Sterno-clavicular Joint.—The small size of the socket of the sterno-clavicular joint relatively to that of the head of the clavicle strongly favors dislocation; and, were the joint not otherwise greatly protected and endowed with a limited range of motion, dislocation would be common. As it is, about one per cent of dislocations are of this joint. (Stimson.)

The sterno-costo-clavicular joint is a ball-and-socket joint, for it permits of flexion in all directions and therefore of circumduction and axial rotation to some degree. The flexion movements take place about axes which are a little external to the head of the bone, and therefore the inner extremity always moves in the direction opposite to that of the outer. Thus, in depression of the shoulder, the upper portion of the capsular ligament and the interclavicular ligament are put on the stretch, and in excessive motion in this direction they are torn and luxation takes place upward. Furthermore, the clavicle finds a fulcrum on the first rib, which fact still further favors upward displacement of the inner end of the clavicle when the shoulder is forced downward. Similarly, forcible backward motion of the shoulder, especially if combined with lateral thrust, will tear the anterior portion of the capsule, producing a dislocation forward, while excessive forward movement of the shoulder will produce a backward dislocation. Backward dislocation is also produced by direct violence applied in front.

In the upward dislocation (Figs. 11, 12, and 13) the head of the clavicle lies in the jugulum and between the sterno-mastoid and sterno-hyoid muscles, while in the forward variety it lies immediately beneath the skin in front of the sternum and the tendon of the sterno-mastoid muscle. In the backward dislocation it lies behind the sternum and generally behind the sterno-hyoid muscle, but the relations to the muscles in this case vary and depend probably on variations of their insertions. In all of these dislocations the joint cavity can be made out by palpation. In all of them, too, the shoulder, lacking the support of the clavicle, which takes the place of a strut, droops downward, forward, and inward in a degree and therefore is narrower than normally, *i.e.*, is nearer the spinal column; but, although its movements are impaired, its function is not entirely lost. The dropping of the shoulder and outer portion of the clavicle in upward and in forward dislocation sometimes causes pressure on the brachial plexus, which results in formication in the upper extremity, or even in serious pressure paralysis. In dislocation backward the head of the clavicle may impinge on the trachea, deep vessels and nerves, causing pressure symptoms in a varying degree and of variable duration.

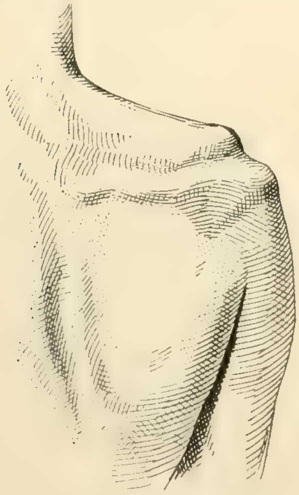

Fig. 11.—Rear View of the Right Shoulder in a Case of Dislocation of the Acromial End of the Clavicle Upward. (After Helferich.) Here the depression of the head of the humerus and the acromion is quite plainly visible.

In a few cases both sterno-clavicular joints have been simultaneously dislocated forward, and in one reported by Geissler ("von Leuthold Gedenkschrift," 1906) both joints were dislocated backward, the trachea being compressed between the two bones.

Sternal dislocation (Figs. 13 and 14) may be complicated by fracture of a portion of the articular surface of the sternum or the clavicle, and in the forward dislocation the head of the clavicle may tear off the insertion of the sternomastoid muscle, stripping up the periosteum of the sternum.

Both ends of the clavicle have been occasionally dislocated simultaneously, to which condition the term total dislocation of the clavicle has been applied.

Habitual luxation of the inner end of the clavicle is not very uncommon and may result from recurrence following reduction of an ordinary dislocation, but it may also occur by gradual stretching of the ligaments of the joint from continual excessive use of the arm, as in base-ball pitching, or from traction of the sterno-cleido-mastoid muscle, as in scoliosis. A case of this sort (Katzenstein, *Langenbeck's Archiv*, LXIX.), due to chronic trauma and recurrent after suture of the ligaments and shortening of the capsule, resulted in pressure paralysis of the brachial plexus, and therefore required further operation. Removal of the meniscus and articular cartilage resulted in cure by ankylosis.

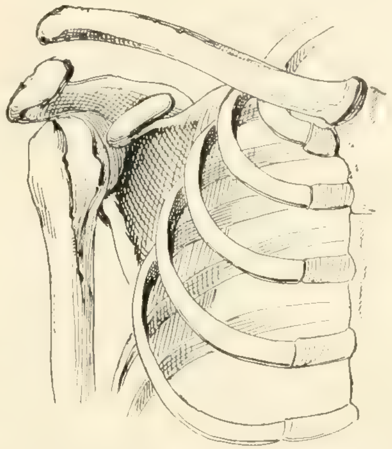

FIG. 12.—Specimen Showing the Relations of the Bones in an Upward Dislocation of the Clavicle. (After Helferich.)

Acute dislocation can generally be readily reduced by making outward traction on the arm and shoulder, at the same time drawing the shoulder forward or backward or upward and making direct pressure on the inner end of the clavicle. Drawing the shoulders backward against the knee placed between them posteriorly is a good method of reducing some clavicular dislocations. In some cases reduction may be most difficult, possibly as a result of displacement of the meniscus, of a complicating fracture, or of locking of the end of the bone behind the sternum. Retention, however, is a different matter and is seldom perfectly accomplished; *i.e.*, after a complete luxation there is practically always left a greater mobility of the inner end of the clavicle than the normal, as well as some degree of abnormal prominence of the head of the bone. Function, nevertheless, is usually perfectly restored.

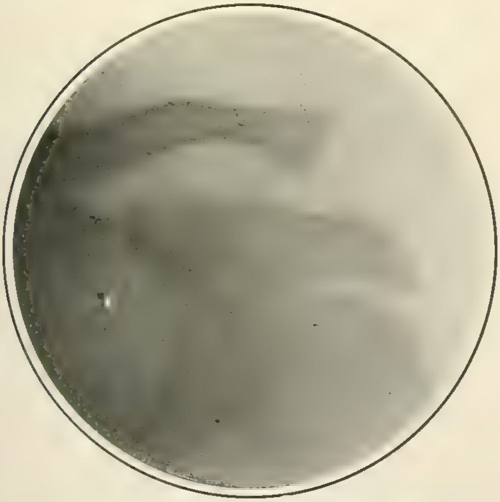

FIG. 13.—Dislocation Upward of the Distal End of the Clavicle. (Roentgen Department of the Lane Hospital, San Francisco.)

Retention is best accomplished by fixation of the shoulder, forward in anterior dislocation, backward in posterior, by a figure-of-8 bandage of both shoulders crossing in front or behind as the case may be. An axillary pad will materially assist, but care should be taken to prevent elevation of the arm. Sayre's apparatus for fracture of the clavicle (Fig. 28, p. 118 of Vol. III.), perhaps combined with compresses at the sternal end, will be found useful in those dislocations in which it is desirable to secure upward, outward, and backward fixation of the shoulder. Such fixation should be maintained for a week or two.

Operative treatment has not been notably successful, probably because of the difficulty in finding ligamentous structures of sufficient strength to hold the necessary sutures. The costo-clavicular ligament should be sutured, and if it is much frayed the sutures should be passed through the bone. In case of habitual luxation various procedures have been tried: excision of the meniscus and the cartilaginous articular surfaces has been resorted to in the hope of bringing about bony ankylosis; Stimson succeeded in two cases with periarticular injections of alcohol.

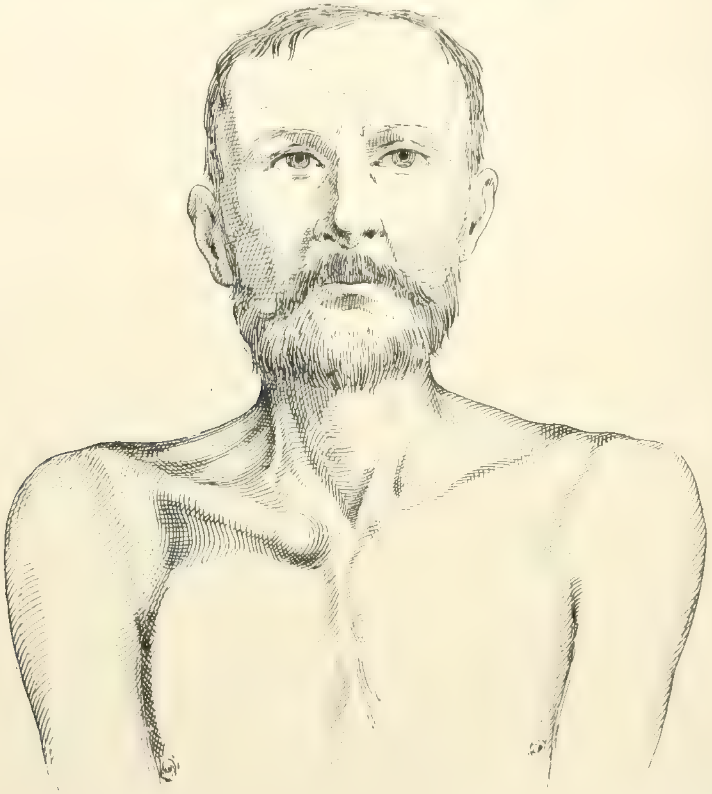

Fig. 14.—Dislocation of the Sternal End of the Clavicle. (After Helferich.) Front view of a man, aged fifty-seven, with dislocation of the right clavicle forward at its inner end. The right shoulder is slighty approximated toward the middle line.

(*b*) Acromio-Clavicular Joint.—The acromio-clavicular joint permits of only very limited motions, and these consist of slidings by which the scapula is permitted to rotate in various directions, chiefly as shown in the elevation and depression of its outer angle. These rotations, supplementing the freer motion of the sterno-clavicular joint, determine the comparatively wide range of motion of the scapula over the chest wall. According to Scudder (*Jour. Am. Med. Assn.*, 1906), who quotes the observations of Kreeke, Poirier, Rieffel, and Sheldon (*Annals of Surgery*, September, 1903) in dislocations, the ligaments limiting these motions are torn as follows: the acromio-clavicular ligaments are torn in all cases, the conoid ligament in all complete cases, and both the conoid and the trapezoid in most complete cases. There is sometimes present a complicating fracture of the lower edge of the articular surface of the clavicle or of the upper edge of the acromion. Dislocation downward or beneath the acromion has occurred, but is rare.

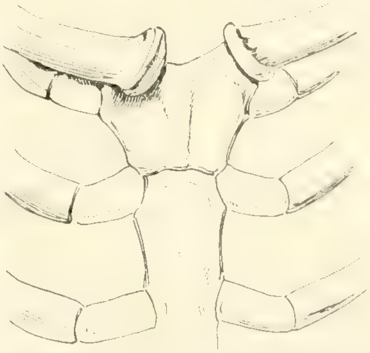

FIG. 15.—Dissection of the Dislocation Shown in Fig. 14. (After Helferich.)

The upward dislocation is practically always produced by a severe blow on the point of the shoulder directed downward and forward. The clavicle is forced relatively upward and makes a prominent swelling beneath the skin over and behind the acromion, which latter is depressed. The shoulder therefore droops and is narrower than the opposite one in complete cases, *i.e.*, does not stand out so far from the spinal column, and the patient is unable to raise his forearm above his head in the normal manner. In some cases there is a good deal of pain, which may persist.

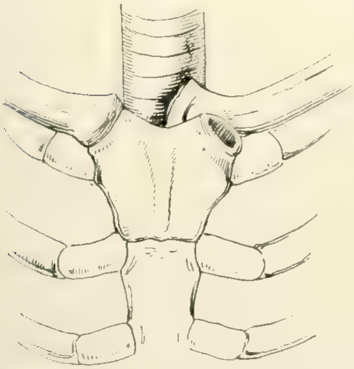

FIG. 16.—Dissection Showing the Relations of the Parts in Dislocation of the Inner End of the Clavicle Backward. (After Helferich.) Note how easily the trachea and œsophagus might be severely compressed as a result of such a dislocation.

Most cases of partial dislocation can be readily reduced and a satisfactory anatomical and functional result be obtained by retention with pads and bandages. This is also true of a considerable proportion of complete dislocations, but in other cases reduction may be impossible owing to the interposition of a torn-off portion of the trapezius muscle, the edge of torn ligaments, or perhaps a misplaced or rotated meniscus. Retention may be difficult because of great muscular power of the patient, or because of an obliquity of the plane of the articular surface, or a complicating fracture or total severing of the ligaments. Even if the bandages applied suffice to hold the end of the clavicle in place, the torn edges of the ligaments, particularly of the conoid and trapezoid, may be so separated that they fail to unite properly. Under such circumstances the displacement persists and in occasional cases the condition is painful. Hence if reduction is not readily effected, or if there is difficulty in retention, or if the original deformity is so extreme that it is probable that the whole ligamentous arrangement of the clavicle is torn, operation should be performed and the ligaments sutured, especially the conoid and trapezoid. It may be found that the ligaments are too much frayed to hold sutures, or are torn off too close to the bone, be it clavicle or coracoid: in which case sutures of kangaroo tendon or wire should be passed through holes drilled in the bone.

The shoulder should be supported by an axillary pad and compresses applied over the outer end of the clavicle. Compresses made of rolls of lint covered with adhesive plaster with the gum side out answer admirably. An excellent bandage for making compression on the outer end of the clavicle is a figure-of-8 passing from the clavicle down behind the arm, up around the flexed elbow, crossing over the clavicle and around the opposite axilla. These turns may be repeated several times and the whole fixed by a few turns around the chest. The forearm should be supported, but the hand and wrist should be left free. A strong bandage thus adjusted and regulated in its tension by a Petit's tourniquet serves an excellent purpose in continued fixation at this joint.

Dislocations of the Humerus.—Practically one-half of all dislocations are of the shoulder joint,—a frequency which cannot but be the result of the sacrifice of stability to the greater necessities of mobility.

The surface of the glenoid cavity, even when extended by its cartilaginous rim, is so small compared to that of the head of the humerus that it serves as little more than a point of support for the latter. In the vertical plane it covers an arc on the head of the humerus of about one-quarter of a circle, ninety degrees, and in the horizontal plane about one-fifth, or seventy-two degrees,—a very different state of affairs from what exists in the acetabulum, which is practically a hemisphere. Furthermore, the capsule is wide and lax, else it would furnish serious limitation of movement. The joint is therefore dependent for stability very largely on the favorable situation of the acromion and coracoid processes, which, with their connecting ligament, make a kind of socket, although at a distance from the head of the humerus, and also in some measure on the tension of the following muscles: subscapularis in front, the supraspinatus and infraspinatus and teres minor behind, and the deltoid enveloping the whole outer aspect of the joint. The four muscles attached to the upper extremity of the humerus, especially the subscapularis, are intimately adherent to the capsule and thus serve to take up the slack of the capsule. This adds materially to the stability of the joint, besides keeping the capsule from being folded between the head of the humerus and the glenoid cavity. The coraco-humeral ligament which, with the supraspinatus, occupies the space between the head of the humerus and the coraco-acromial ligament, is of similar importance in relation to luxation of the shoulder as is the Y-ligament of the hip in dislocations of that joint.

The shoulder joint permits of movement in all directions and therefore of circumduction as well as axial rotation in all positions of the humerus. One may conveniently consider these motions as rotations in three planes at right angles to one another. In the lateral vertical plane the humerus may be raised roughly to the horizontal (abduction) and depressed to the side of the chest (adduction). Further adduction is possible if the shoulder is raised. In the anterior vertical plane the humerus can be raised to about one hundred and forty degrees before the scapula is tipped backward, the arrest at this point being effected by the acromion process and the coraco-acromial ligament. This movement, which occasions a marked twist in the capsule, is favored by the normally oblique direction downward of the anterior portions of the capsule (gleno-humeral ligaments). This very obliquity of the fibres of the anterior portion of the capsule, however, serves powerfully to prevent elevation of the humerus posteriorly.

In the horizontal or transverse plane passing through the shoulder joint the humerus can be abducted to the plane of the back, at which point it is arrested by contact of the greater tuberosity with the posterior edge of the glenoid fossa and by the tension of the anterior ligaments. It can be adducted, however, until arrested by the chest wall.

The attachment of the long head of the triceps at the lower border of the glenoid fossa—the muscle being flat in a roughly antero-posterior sense and the edge therefore being toward the humerus—furnishes a natural plane of division between forward and backward dislocations, but, more than that, it is a determining factor in many cases of subglenoid dislocation. Finck, of von Bruns' clinic, has shown that about 97.5 per cent of all shoulder dislocations are forward, while only 2.5 per cent are backward. This extraordinarily greater frequency of forward dislocations is further accounted for by the fact that most dislocations of the shoulder are produced by "lever action," the long arm being the shaft of the humerus and the short arm the head of the bone. The only point where a bony fulcrum can develop is above, where one or other of the tuberosities, generally the greater (depending on the degree and direction of rotation), impinges on the upper edge of the glenoid ligament. Excessive elevation of the arm laterally or anteriorly by "lever action" lifts the head of the humerus off the glenoid cavity, and further elevation transfers the fulcrum to the edge of the acromion. The fact that the spherical articular head proper of the humerus projects inward from the shaft makes it evident that there can be no bony fulcrum on the lower portion of the neck of the humerus, or on the inner side of the bone.

Although blows are received more frequently on the front of the shoulder than from behind, and notwithstanding the fact that the acromion provides great protection against blows from behind, still dislocation, even when due to direct violence, is more common forward than backward, because the glenoid cavity, by its deviation forward (nearly forty-five degrees), offers great bony resistance to displacement backward.

The primary positions of the head of the humerus in dislocation are difficult to determine because seldom observed, but they are probably few in comparison with the secondary positions; so much depends on the point where the causative forces cease to act and on the character and direction of additional forces which are active after the head of the bone has left the joint.

In all but very rare cases dislocation of the shoulder is produced by "lever action," as said above, or by thrust from above and behind, in either of which cases the capsule is torn below or in front, the head of the bone passing through the rent. If the arm is still held in extension and force be active in the direction of the shaft of the humerus, the head of the bone is driven quite a long way through the rent in the capsule and deep down into the axilla. The capsule may be partly turned inside out or widely ripped off the bone. Untorn portions of the capsule and the muscle attached to the tuberosities, and particularly those muscles attached to the shaft lower down (teres major, pectoralis major, and latissimus dorsi), furnish a fulcrum, and the upper extremity of the humerus, then being a relatively long short arm of the lever, prevents elevation of the head of the humerus. The so-called luxatio erecta—one of the rarer dislocations of the shoulder—results; the head of the bone, having passed downward behind the subscapularis and in front of the teres major and latissimus dorsi muscles, lies on the chest wall, and the arm remains extended above the head.

In the more usual dislocations the arm is brought down to the side before the head of the bone has passed far enough through the rent in the capsule. Depending very largely upon the degree of this protrusion, the amount of tearing off of the capsule from its humeral attachment, etc., the head of the bone will lodge beneath the lower edge of the glenoid cavity in front of the long head of the triceps (subglenoid dislocation), or higher up in front of the glenoid, more or less external to the coracoid (preglenoid dislocation), or beneath the coracoid (subcoracoid dislocation), or even internal to it (intracoracoid dislocation).

In high dislocations forward, due for the most part to direct violence,—*e.g.*, blows on the back of the shoulder,—the head of the humerus may slip over the upper border of the subscapular muscle, or may tear through its lower portion,—an occurrence which is favored by the attachment of this muscle to the capsule, or it may dissect it up from the surface of the scapula; but much more commonly it passes beneath the edge of the subscapularis and lodges anteriorly to it, or presses untorn portions of the muscle upward against the coracoid.

In the production of most of these so-called secondary positions the movements of the head of the humerus are constrained and largely determined by the strong coraco-humeral ligament acting as a fulcrum.

Dislocation backward is produced by longitudinal thrust on the elevated and adducted humerus and is probably favored by internal rotation. It is possible that in a few cases of subglenoid dislocation the humerus may be forcibly lowered in adduction and the head of the bone slip over the long head of the triceps. In its secondary position the head of the humerus may lie on the posterior surface of the infraspinatus muscle, or, more rarely, beneath it. Dislocations backward are commonly subacromial, but greater penetration of the head through the rent in the capsule will permit still further displacement inward, and the dislocation will then be subspinous.

Farabeuf thought that in a case seen by him the head of the humerus had been forced, by a movement of circumduction, downward and backward beneath the long head of the triceps, *i.e.*, between it and the edge of the scapula. This subtricipital dislocation of Farabeuf is a theoretical possibility, but the few cases that have been observed as perhaps presenting this condition have been doubtful and more than probably were merely low posterior dislocations. (Stimson.)

Dislocation upward of the head of the humerus has been observed, in all, in fourteen cases (histories of all of them detailed by Stimson), most of them having been seen months or weeks after the occurrence of the injury, and only a few in the recent state. As far as known they were produced by blows on the elbow, the arm being down at the side. It would also appear that rotation of the humerus outward and elevation of the shoulder favored this dislocation. The extreme rarity of dislocation upward is probably to be explained, not on the rarity of blows on the elbow, but on the elastic yielding of the scapula as a whole upward, thereby taking up the thrust before displacement occurs.

The displacement of the humerus in the fourteen cases referred to above was not great—1 or 2 cm. ($\frac{2}{5}$ – $\frac{4}{5}$ in.)—and the head of the humerus impinged on the anterior and under surface of the clavicle. In several of the cases the coracoid or the acromion was fractured. The capsule was not necessarily ruptured.

The following classification (Stimson) embodies the tendency of modern writers on dislocations to simplification—restricting the group of the "subglenoid" and enlarging that of the "subcoracoid":—

Forward..............................	Subcoracoid; very common. Intracoracoid; exceptional. Subclavicular.
Downward..............................	Subglenoid; uncommon. Erecta; very rare. Subtricipital (?).
Backward..............................	Subacromial; rare. Subspinous; very rare.
Upward..............................	Supraglenoid; very rare.

Dislocations Forward.—In dislocation of the head of the humerus forward the normal rotundity of the shoulder is lost, the acromial process being prominent and giving the shoulder a pointed appearance. There is more or less of a concavity beneath the acromion laterally, and internally there is a fulness. The arm is somewhat abducted, and its axis, prolonged upward, instead of meeting the acromion a little internal to its tip, passes internally to this point to a degree depending on the displacement inward of the head of the humerus, although with elevation of the head the obliquity is less than when the head is lodged beneath the glenoid cavity. In the purely subglenoid dislocation the head of the bone is so depressed and the outer parts of the capsule are so tense that the arm is often greatly abducted, so that its axis passes through the middle of the clavicle. In a case of intracoracoid dislocation reported by Bardenheuer the arm was held in horizontal abduction.

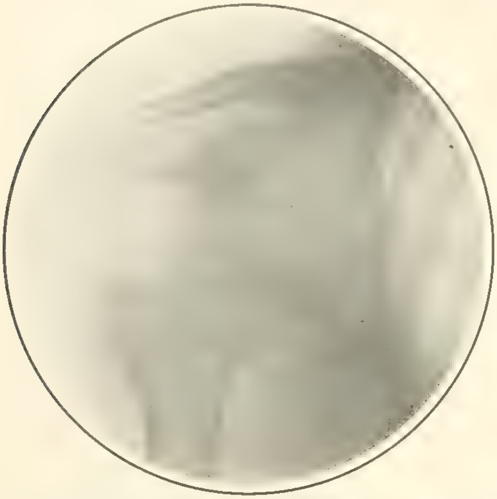

Fig. 17.—Dislocation of the Head of the Humerus Forward, with Fracture of the Greater Tuberosity. (Roentgen Department of Lane Hospital, San Francisco.)

Palpation demonstrates the absence of the head of the humerus beneath the acromion and shows its true position with reference to the bony landmarks, although the coracoid in many cases cannot be felt. It shows also a marked increase in the distance between the tip of the acromion and the shaft of the humerus high up in the axilla. (Fig. 18.) In complicating fracture, crepitus may be detected, but later effusion of blood and œdema may obscure the findings of palpation.

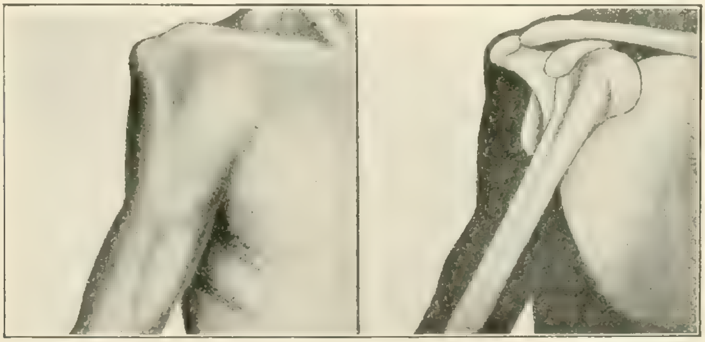

Fig. 18.—Intracoracoid Dislocation of the Humerus. (After Lejars.)

Attempts to bring the elbow to the side demonstrate an elastic resistance which is quite the contrary to the finding in fracture of the neck of the humerus.

The arm may appear slightly longer than its fellow, but, on measurement from the tip of the acromion, it is generally found slightly shortened. In the intracoracoid dislocation or the subclavicular the shortening is more pronounced.

In recent dislocation active movement of the arm is prevented by the abnormal tension of the muscles and by the soreness, but a considerable degree of passive motion is possible outward and forward. In preglenoid dislocation the head of the humerus may be rotated about the edge of the glenoid depression,—the latter lying in the sulcus between the greater tuberosity and the articular surface—and in this motion the head can be felt to describe an arc with longer radius than when similar rotation is attempted in the more distinctly characterized inward dislocations, because in the latter rotation is more nearly axial.

An important point in the differentiation of dislocation from fracture of the glenoid cavity, or of the neck of the scapula, both of which conditions produce a similar deformity, is that in the latter the deformity is readily overcome, but at once recurs when pressure is released.

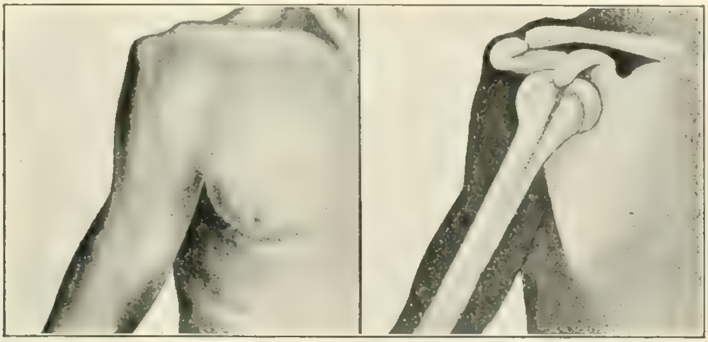

Fig. 19.—Subcoracoid Dislocation of the Humerus. (After Lejars.)

In subglenoid dislocation, besides the obliquity of the axis of the arm above mentioned, there are greater flattening of the deltoid region and greater tension of the deltoid muscle. The arm may be slightly lengthened as measured from the tip of the acromion. The head of the humerus is plainly to be felt in the axilla and perhaps a finger's breadth below the coracoid. Dugas' sign is of importance and can be promptly employed. It is this: If the hand of the injured extremity be placed on the sound shoulder the elbow cannot touch the side of the chest; or, *vice versa*, if the elbow touch the side of the chest, the hand cannot be placed on the sound shoulder.

Treatment.—In uncomplicated forward dislocations of the humerus, reduction can generally be effected without difficulty in the early stages before effusion and swelling have occurred, and for the most part without anæsthesia. However, if the patient be powerfully muscled and particularly if he be under the influence of alcohol, anaesthesia will generally be required before the muscles will relax sufficiently to permit of replacement of the dislocated bone.

Many methods of reduction have been devised, some general in application and others designed to meet specific indications. They may be roughly classified as methods of direct reposition by manipulation, by traction with or without manipulation, by leverage, generally combined with traction, by rotation, and finally by open incision.

Space will not permit of the detailed description of more than a few of these methods, but before we consider them attention should be drawn to the more evident causes of difficulty in reduction, on which in given cases choice of method may very largely depend. In general, the milder methods should be tried before resort is had to methods using much force, and if possible a Roentgen picture should be obtained in order to exclude fracture with displacement of a fragment as the hinderance to reduction.

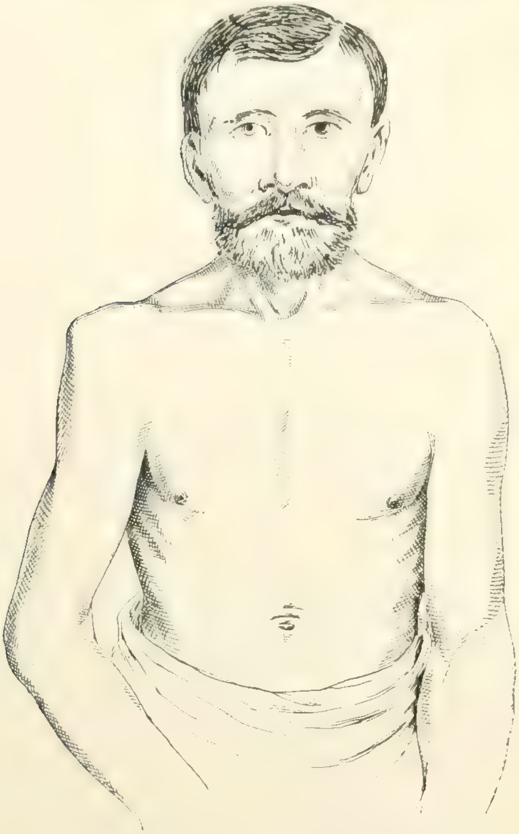

FIG. 20.—Subcoracoid Dislocation of the Humerus of Three Weeks' Standing. (After Helferich.) Note the decided projection of the acromion and the angle made by the outer contour of the abducted arm; the axis of the arm being directed toward the coracoid process instead of toward the acromion. The length of the dislocated arm appears to be increased.

According to Doellinger tension of the subscapularis muscle is one of the most common and important hinderances to reduction of forward dislocations. In Kocher's method of reduction this muscle is stretched by rotation outward. In case of fracture of the minor tuberosity the muscle may pull the fragment inward and cause it to interfere with reduction. The rent in the capsule may be a simple slit and offer great resistance to the passage of the head, especially if the capsule be torn from its humeral attachment anteriorly. Fracture of the external or greater tuberosity is rather common and sometimes the fragment falls into the joint. It is then large enough materially to hinder reposition. The long tendon of the biceps is not infrequently slipped from its groove and may lie along the posterior side of the head of the humerus, or it may be torn apart and fall into the joint.

Fracture of the rim of the glenoid cavity may so lessen the support of the head of the humerus that there will be great difficulty in preventing the head from slipping off. Such a case would be on the border line between fracture of the glenoid and dislocation of the humerus with fracture of the rim of the glenoid as a complication.

Simple lifting of the head of the bone upon the glenoid cavity. (Method of Avicenna.)—When this method is employed, the patient sits, letting the arm hang by the side. The operator fixes the scapula with one hand on the acromion and lifts the head of the humerus outward and upward, perhaps at the same time making moderate abduction. If the patient can relax his muscles, the dislocation, in many of the fresh cases, can be thus reduced. It is of advantage for the operator to stand behind the patient and let the elbow of the dislocated arm rest on his forearm, as in this way he will be able to make the desired degree of abduction without additional assistance.

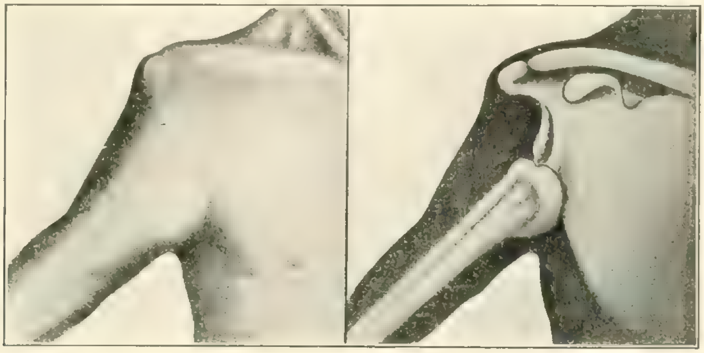

Fig. 21.—Subglenoid Dislocation of the Humerus. (After Lejars.)

Traction laterally.—The patient may sit or may lie on a table, and while one assistant fixes the scapula by means of a swathe passed around the chest, or by a wide bandage with a hole in it large enough to pass the arm through, another makes traction directly outward and forward. The operator may materially assist by pressure with fingers on the head of the humerus, making counter-pressure with his thumbs on the olecranon.

When it is found that the posterior fibres of the deltoid make strong resistance to reduction, Riedel ("Heilkunde," 1899) advises, in most cases of forward dislocation of the shoulder, making strong traction toward the hip of the sound side, when a smart blow on the hand will often throw the head of the bone into place.

In Simon's method the patient lies on his side and the arm is pulled laterally by means of a line passing over a pulley in the ceiling. The patient's whole weight may thus be brought into play as the traction force.

Stimson arrives at the same result in a much more comfortable and safer way, by placing the patient on his side on a canvas couch, his arm passed through a hole in the canvas near one end, and a weight of from ten to twenty pounds being attached to the hand or forearm. (Fig. 22.) Of course the cot should be high enough from the floor to permit of the extension being effective. After a time the muscles, which may be in a state of spastic contraction, will give way from sheer fatigue and the dislocation be reduced. Manipulation may be of some assistance. This method is perfectly safe, is effective, and does not inflict any injury.

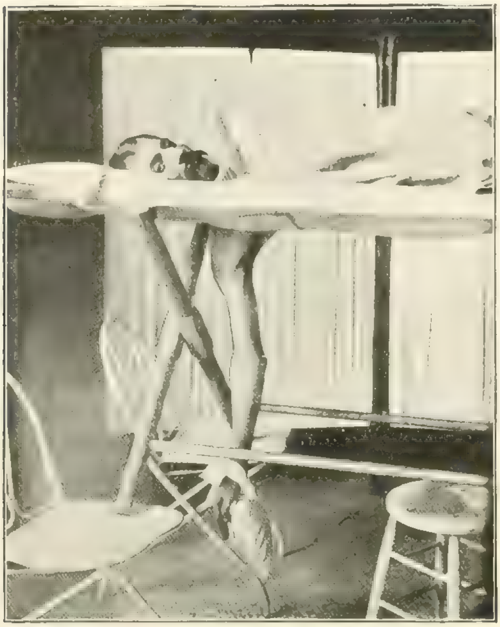

Fig. 22.—Stimson's Method of Reducing a Dislocation of the Shoulder.

Traction vertically.—Mothe's method reproduces approximately the position of the arm at the moment of dislocation. The patient sits on a chair, and the operator makes forcible traction directly upward in a direction parallel to the side of the head, counter-traction being supplied by a bandage over the shoulder, or by the operator's foot on the acromion, the operator standing on a high stool or table. The same manœuvre may be carried out with the patient on his back and the scapula fixed by two swathes—one around the body and another over the acromion. This method is not without danger, for laceration of the axillary vessels has resulted from too great traction while the vessels were stretched over the head of the humerus. If used at all, it should be carried out with great caution.

Leverage with traction.—Sir Astley Cooper's method.—The patient sits on a chair and the operator, standing behind the patient with foot on the chair beside him, passes the dislocated arm over his own flexed knee, making traction with one hand and pressing with the fingers of the other on the humeral head. More commonly the patient is made to lie on the floor and the operator's heel is placed in the axilla for a fulcrum, while traction is made on the patient's outstretched hand. This method is also not free from danger, for the force which can be thus exerted is far greater than one would suppose and may lacerate the vessels or break the bone. The writer once had occasion to wire a longitudinal fracture of the humerus produced in this manner in a dislocation which was not more than an hour or two old. One fault with the method as thus applied is that the traction is made downward rather than in the more advantageous direction outward and forward.

Schinzinger's method, by rotation.—The arm is adducted to the side of the chest, and the forearm, flexed to a right angle, is used as a lever to rotate the humerus outward till the inner side of the arm looks directly forward. In subcoracoid dislocations this throws the greater tuberosity upon the anterior edge of the glenoid. An assistant then presses the head and upper humeral shaft outward when the operator makes a sudden rotation inward.

Kocher's Method.—Kocher has modified Schinzinger's method to the extent of raising the elbow forward after rotating it outward and circumducting the arm till it lies well across the chest, then rotating it inward. In some cases it is of advantage, instead of pushing upward on the humerus, to make moderate traction in the direction of the hip of the sound side as the arm is lifted over the chest. (Terry, San Francisco.) The method of Kocher, which has become one of the most popular methods of reducing forward dislocations of the head of the humerus, is based on the fact that the coraco-humeral ligament is seldom ruptured and may be utilized as a fulcrum, in the adduction, to cause the head of the humerus to rise forward and outward well beyond the coracoid process. The external rotation, as in Schinzinger's method, utilizes the point of contact of the greater tuberosity with the anterior edge of the glenoid cavity as a fulcrum for the elevation of the head over the glenoid border.

The fundamental disadvantages of the method by rotation are that by the outward rotation the subscapular muscle and the anterior portion of the capsule are put greatly on the stretch, and that, in case the head of the bone is in front of the muscle, or the muscle is torn, the head of the bone will force portions of the muscle into the joint. Furthermore, the leverage is enormous and it requires but little force to break off the head of the humerus, as once occurred in the hands of the writer. After this accident operative removal of the severed head is indicated. Kocher published 28 cases treated by his method, with 25 successes, but with 3 fractures! (Koenig.) It is doubtful if the method by rotation possesses any real advantages over other and less dangerous methods.

Traction in three directions.—The trunk, together with the scapula, may be fixed by a wide swathe passed around the chest and over the shoulder, or by a stout piece of muslin with a hole in it large enough to permit the arm to be passed through and held by one or two assistants; the arm is pulled outward and downward by two or three assistants, and, by means of a swathe passed beneath the axilla, traction may be made upward. By such means great force can be applied and will every now and then succeed where other methods fail; but, like all methods where great force is used, it is dangerous. The writer has personal knowledge of one case in which such traction caused fracture of the neck of the humerus in a case of subcoracoid dislocation only two weeks old.

The methods of lateral traction by pulleys are open to the same objections and often cause great damage in spite of dynamometer and releasing forceps. Jarvis' adjuster is of historical interest in this connection. In one case seen by the writer, in a subcoracoid dislocation which had resisted other methods of reduction and in which open operation was refused, traction by pulleys failed to bring about reduction and was followed by paralysis of the arm, which had not completely disappeared as long as a year after the attempt at reduction. The joint was finally resected.

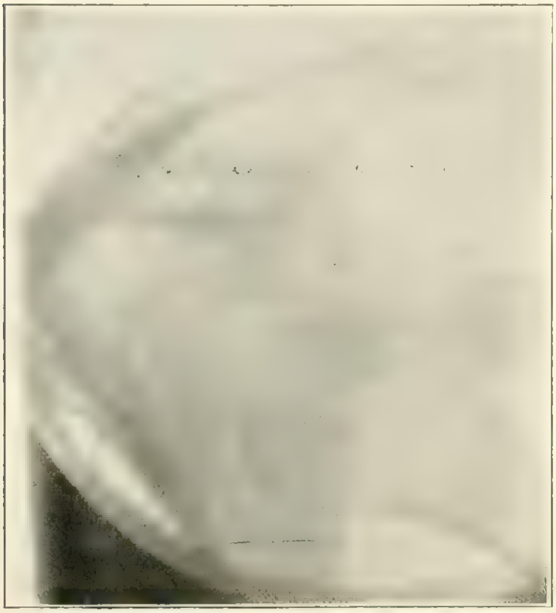

FIG. 23.—Subcoracoid Dislocation of the Humerus with Fracture of the Greater Tuberosity. (Roentgen Department of Lane Hospital, San Francisco.)

Complications.—Fracture of the surgical neck of the humerus with concomitant dislocation is a rare injury, but occasionally occurs. (Fig. 23.) Perhaps more frequently the fracture is the result of an injudicious use of force in the attempt to reduce the dislocation. In recent cases it is sometimes possible to reduce the dislocation by relaxing the muscles and lifting the head of the bone upon the glenoid cavity by means of the finger in the axilla. More often, however, open operation is required. In the procedure of McBurney the fragment is first exposed, and then a hole is drilled in whatever remnant of the shaft there may be on the upper fragment, and a hook or a stout wire is passed through it. This wire twisted into a loop permits, like the hook, forcible traction to be made. After reduction, which is thus quite readily accomplished, the wire may be threaded through a corresponding hole in the upper portion of the lower fragment for the purpose of fastening the two ends together. With a proper aseptic technique this procedure is preferable to waiting for the fracture to heal and then attempting to reduce the dislocation by the ordinary methods.

Injuries to the brachial plexus or its branches are not uncommon as complications of dislocations of the shoulder. The circumflex nerve is particularly liable to injury, and as a result there is apt to be more or less permanent paralysis of the deltoid muscle. The paralysis may not be noticed for some weeks—that is, during the time when the arm is fixed in the dressing and for some time afterward. If discovered thus late it is apt to be referred by the patient to the bandage rather than to the dislocation, and great injustice may thereby be done the surgeon. It should not be forgotten that even momentary pressure on such a nerve as the circumflex may give rise to degeneration and permanent paralysis.

Injuries to the blood-vessels occur so much more frequently in efforts at reduction of old dislocations that it has seemed convenient to discuss them under that heading.

Dislocations Backward.—In the so-called subacromial or subspinous dislocation, the head of the humerus, lying posteriorly beneath the acromion, manifests its presence by a prominent rounded swelling in this situation. In front, the normal rotundity of the shoulder is lost, and both the acromion and the coracoid stand out sharply. Palpation further shows the presence of a hollow in the usual position of the head of the humerus, and in some cases the glenoid cavity can be felt. The arm is for the most part slightly shortened and is not easily approximated to the side.

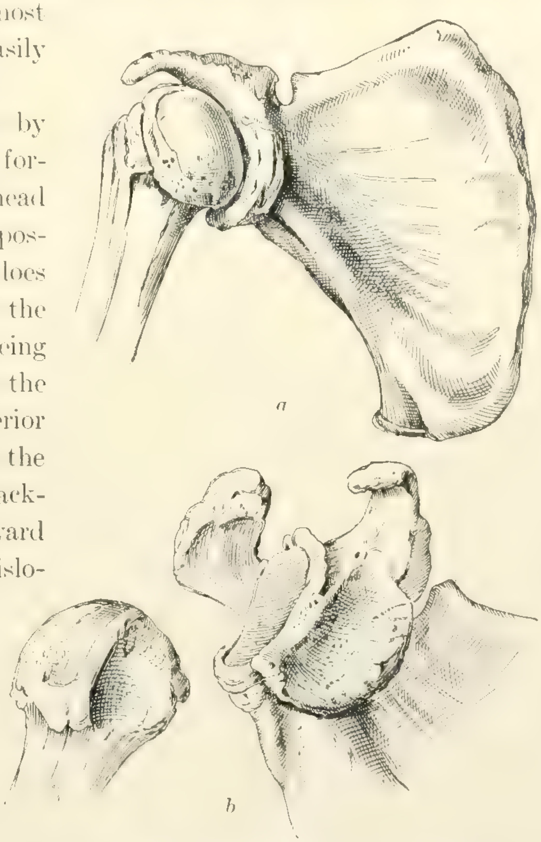

Fig. 24.—Bony Specimen of an Old Subcoracoid Dislocation, Showing the Formation of a New Glenoid Cavity and the Wearing Away of the Head of the Humerus. (After Helferich.) In *a* the bones are placed in their natural relations; in *b* they are separated.

Reduction is readily effected by elevation of the arm, traction forward, and direct pressure on the head of the bone from behind. The posterior edge of the glenoid cavity does not present so sharp a projection as the anterior, and hence, other things being equal, less force is required to lift the head of the bone out of the posterior fossa. Rotation inward possesses the same value in the reduction of backward dislocations as rotation outward does in the reduction of forward dislocations. A greater tendency to recurrence than in forward dislocations has, however, been observed

Old Unreduced Dislocations. — Dislocations of the shoulder may, in certain rare cases, be practically irreducible from the very beginning because of complications elsewhere indicated, but reducible cases as a rule become more and more difficult of reduction as time goes on. However, in individual cases reduction has been effected after many months and even after years.

In a considerable proportion of cases of unreduced dislocations of the shoulder function is gradually restored to a considerable degree, even in some cases a new joint forming about the head of the humerus. (Fig. 24.) Still, while such a joint may be useful, the range of mobility is always limited, and every now and then a patient will present himself for relief. Then, again, there may be almost no motion or the region may be painful.

Since, as stated above, dislocations of even long standing have been reduced, it is right to make the attempt in a given case, preferably after a Roentgen picture has been taken. The various methods mentioned above may be tried under anaesthesia and after thorough breaking up of adhesions and stretching of contracted muscles, particularly the subscapularis. With modern aseptic technique, however, open incision has displaced the use of such great force as was formerly often employed.

Doellinger (*Zeit. f. Chir.*, 1903) reported 19 old subcoracoid dislocations treated by him in the previous five years. In one there had been concomitant fracture of the neck of the humerus, but the callus of three months was considered too weak for the use of ordinary methods of reduction; hence he opened the joint and found reduction easy by means of rotation outward. In two cases the humerus was fractured in efforts at reduction and the luxation remained. In 10 cases he performed an open operation; in one with fracture of the surgical neck he performed resection; in another a fractured greater tuberosity lay in the glenoid cavity, after the removal of which reduction was effected without difficulty; in 7 cases simple section of the subscapsular muscle permitted reduction by Kocher's method. Doellinger is firmly of the opinion that shortening of the subscapular muscle is the real obstacle to reduction in many cases and that this muscle must be cut or torn across in order to make reduction possible.

The relative values of reduction by open operation and resection of the head of the humerus have not yet been satisfactorily established. The functional results of resection are so good that many operators have been led to prefer it to operative reduction. In old dislocations, successful reduction does not guarantee useful function. Muscles are contractured, various structures are adherent, cicatrices more or less firm interfere with the movement, and organized exudates without or within the joint may be slow to undergo absorption. With these things in view it is evident that operative reduction is chiefly applicable to recent dislocations which are otherwise irreducible. Smitel, quoted by Koenig, collected 15 cases of reduction by open operation, in 5 of which resection was afterward done and 5 were reported as improved, 3 unimproved, and 2 dead. On the other hand, of 32 old dislocations in which resection had been performed, there were 20 in which good functional results were secured.

Injuries of blood-vessels in connection with dislocations of the shoulder are not very uncommon. Nemenoff (Inaug. Diss., Berl., 1905) collected 65 cases from the literature, mostly injuries of the axillary artery, or of one of its larger branches, or the tearing across or pulling out of large branches. In 8 cases the axillary vein was torn, in 2 both artery and vein, and in 1 case (Malgaigne) the vessel, which had given rise to an immense hæmatoma, could not be found. Probably, in this case, a large number of minute vessels were ruptured. In 15 cases (one-fourth) the injury of the vessels occurred in fresh dislocations, the remainder in old. Of the 65 cases 31 were in patients over 50 years of age, 6 over 40, 14 under 40, and in 14 the age was not reported. In 11 cases the artery was ligated, in 1 the vein. Of these 12 patients operated on, 6 died and 6 lived (2 with loss of function); 2 lost the whole arm and 1 the forearm. In all, 4 amputations were performed. The increase in the frequency of the injuries of the blood-vessels was fairly proportionate to the length of time the dislocation had existed before the attempt at reduction was made. In a very small proportion of the cases was the injury of the vessels primary, *i.e.*, due to the dislocation itself.

HABITUAL DISLOCATION.—Habitual dislocation occurs far more frequently in the shoulder than in any other joint of the body and has been the field of much ingenious operative work. Every time the joint is dislocated from any cause, the tendency to dislocation is definitely increased. Epileptics not infrequently suffer from habitual dislocation of the shoulder.

The patient with habitual dislocation is obliged to keep the fact constantly on his mind lest he make some movement which will throw his shoulder out. In a case within the knowledge of the writer the shoulder becomes dislocated whenever the arm is raised, and the patient, an athletic man, fond of swimming and out-of-door sports, is obliged to strap his arm to his side whenever he essays swimming or boating.

Anatomically there are various causes for habitual dislocation—simple laxity of the capsule from overstretching, tearing off of the capsule from a part of its humeral or its glenoid insertion, the stretching of a large scar in the side of the capsule, fracture of the edge of the glenoid cavity, particularly anteriorly, tearing off of the glenoid ligament, fracture of one or other of the tuberosities, tearing off of one or other of the muscles supporting the joint, particularly the supraspinatus and the infraspinatus, paralysis of these muscles, etc.

Resection of the head of the humerus has been proposed as a cure, on the ground that the head, not being present, cannot be dislocated (Koenig); but it is a radical procedure which will seldom be agreed to by patients. Nevertheless, the functional results are satisfactory. A case has recently been reported by Warren (*Bost. M. and S. J.*, 1903) with satisfactory functional result following resection. Many operations have been devised for taking up the slack of the capsule: excision of portions of it, "reefing," etc. Krumm (*Münch. med. Woch.*, 1899) reported a case in which he had operated for a dislocation that had recurred thirty-seven times. He opened the sheath of the biceps tendon, dislocated the tendon outward, dissected the capsule free above and in front, and folded it, taking a reef in it with catgut. A year afterward there had been no recurrence.

In poliomyelitis arthrodesis has been advised, but the choice of operation should be determined by the peculiarities of each particular case. In epileptics resection will probably be the most satisfactory procedure.

In a notable article on habitual dislocation (with full bibliography) in the Bergmann "Festschrift" (*Deut. Ztschr. f. Chir.*, Dec., 1906) Perthes reports four cases operated on by him in which he sought to restore the normal relations of the torn structures. He follows Hildebrandt, who first re-attached the capsule to its proper insertion. Perthes chose his incision along the anterior border of the deltoid, or he employed the posterior incision of Kocher for resection, according as the suspected trouble was in front or behind, and he lifted off whatever muscles interfered with his reaching the region desired. In the first case he made an incision from the coracoid to and around the insertion of the deltoid, cutting across the lower end of that muscle, lifted it bodily off the humerus, and turned it backward, taking care not to injure the circumflex nerve. He then was able to attach the torn off insertions of the supra- and infraspinatus by means of a staple driven into the greater tuberosity. In the second case he exposed the same region by Kocher's posterior incision, chiselled off the acromion and part of the spine of the scapula, fastened the infraspinatus, and took a reef in the capsule with silk sutures. In the third case he cut across the outer part of the greater pectoral muscle, made a temporary resection of the coracoid to get the biceps and coraco-brachialis out of the way, and re-attached the torn-off edge of the glenoid cavity. In the fourth case he reefed the anterior portion of the capsule with sublimate silk sutures. All four cases had been operated on more than a year before being reported and none had had recurrence of the dislocation in that time, although two of them were in epileptics having frequent seizures. After operation passive motion was begun at the end of from two to three weeks.

Dislocations of the Elbow.—The trochlear surface of the humerus, at least in its centre, comprises almost a complete semicircle on which the sigmoid surface of the ulna makes an arc of about one hundred and eighty degrees, thereby permitting extension and flexion movements of about one hundred and fifty degrees, the head of the radius following on the eminentia capitata the movements of the ulna. Extension is limited by contact of the olecranon with the humerus in the olecranon fossa and by the tension of the anterior ligaments, especially the strong band leading from the internal condyle to the coronoid process and the strong anterior portions of the internal lateral ligaments and the flexor muscles, while flexion is limited by contact of the anterior muscles of the forearm and humerus with the latter bone and by tension of the posterior ligaments and the triceps muscle. The anterior ligaments are much thicker and stronger than the posterior.

In children, from incomplete development of the olecranon and the coronoid process, the arc covered by the sigmoid surface of the ulna is less than in the adult, by reason of which mobility is greater and stability correspondingly less. The internal condyle is little developed in the child, the carrying angle is less, and the trochlea is more nearly cylindrical, *i.e.*, its groove is shallower. Furthermore, in children the olecranon and the coronoid, being largely cartilaginous, yield to bending and compressing forces more than do the more rigid bones of the adult elbow, permitting more lateral flexion. It is for these reasons that the same violence which in the adult produces dislocation of the shoulder, in the child produces dislocation of the elbow. In many young people, more particularly girls, the forearm may be extended to several degrees beyond the straight position (dorsal flexion).

The head of the radius is held in contact with the semilunar fossa of the ulna by the stout orbicular ligament which is attached to the ulna at each extremity of the semilunar fossa, but is also continuous above with the anterior capsule of the joint.

Dislocations of the elbow are caused by exaggerations of the normal movements of the joint, by forced flexions and rotations in various abnormal directions, and by thrust directly applied to the bones near the joint or transmitted through the forearm. Clinically, by far the largest number of dislocations of the elbow are the result of falls forward on the outstretched hand. Of great importance in this regard is the fact that thrust is transmitted from the hand to the humerus chiefly by means of the radius, a fact which more than any other explains the production of isolated dislocations of that bone. The direction of such thrust changes very considerably with change of position of the radius in pronation and supination. The ulna does not come into play in transmitting thrust till the radius has either left the articular surface of the humerus or is broken somewhere in its length, and then the head of the ulna is so small that it will pass through the soft tissues below it before it will transmit enough force to dislodge the broad contact of the sigmoid surface from the trochlea.

Of importance, as an aid in diagnosis of both fractures and dislocations, is the fact that the internal and external epicondyles, as well as the olecranon, are nearly always to be felt beneath the skin. Only in cases of great swelling are they obscured and even here they can be made out in most cases after continuous pressure is made by the fingers for a short time, by which procedure the œdematous fluid is forced out of the particular regions. Normally, with the arm in extension these three points are in a plane transverse to the shaft of the humerus, while with the forearm flexed to a right angle this plane has also rotated through a right angle and lies nearly vertically.

Of importance also is the so-called "carrying angle," the angle of the physiological abduction due to the inclination of the axis of the trochlea to the shaft of the humerus in the lateral plane. This angle varies greatly in individuals, corresponding largely to the width of the hips. It is thus less in children than in adults and is less in boys than in girls. In fact, in some boys it is absent altogether. In case of injury of the elbow comparison with the sound arm is of great diagnostic value and should always be made.

Just below the centre of the sigmoid fossa the cartilage is interrupted by a transverse sulcus which marks the point of fusion of the olecranon with the shaft of the ulna and in young children is the site of the epiphyseal cartilage—a point of weakness where fracture of the olecranon most frequently occurs.

About one-fifth of all dislocations are of the elbow, which therefore is easily second to the shoulder in the frequency of this accident. Dislocations of the elbow are divided into two groups: first, dislocations of both bones, and, second, dislocation of one or other of the bones of the forearm singly. Dislocations of both are further divided into forward, backward, outward, inward, and divergent (ulna backward and radius forward). Similarly, dislocation of single bones may be of the ulna backward or of the radius forward, outward, or backward.

In 222 cases in St. Thomas's Hospital (Makins) 109 were backward, 52 backward and outward, 18 outward, 6 backward and inward, divergent 6, forward 1, double 1.

Dislocations of Both Bones Backward.—As a rule, posterior dislocation of both bones backward is produced by a fall forward on the outstretched hand, but it may result from a thrust backward when the forearm is partly flexed, as happens from a sharp fall on the keel of the ulna or from a blow on the back of the lower end of the humerus. Malgaigne thought that rotation, especially external, such as would be produced by a fall on the inner edge of the olecranon, might produce a dislocation backward. (Figs. 25 and 26).

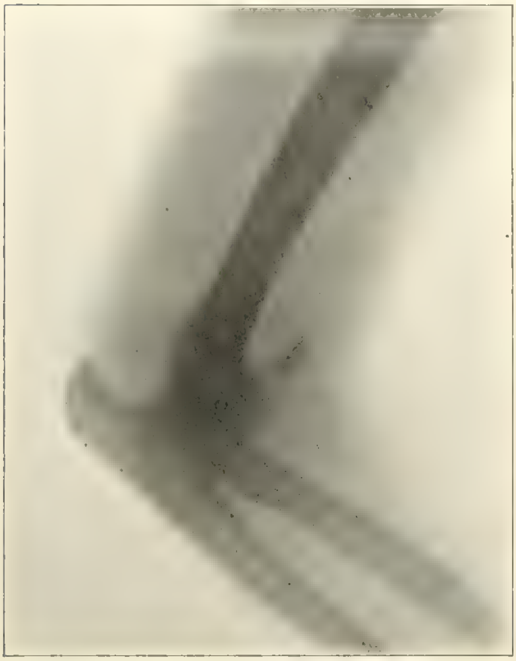

Fig. 25.—Dislocation of Both Bones of the Forearm Backward, with a Fragment of the Coronoid Process in Front, and a Small Fragment within the Joint Behind. (Roentgen Department of Lane Hospital, San Francisco.)

A case of compound posterior dislocation of both bones, which came under the care of the writer for ankylosis, the result of infection, and in which resection gave an excellent functional result, was caused in a wrestling bout by a sudden giving way of the anterior ligaments while the arm in complete extension was supporting most of the weight of the patient and his opponent. The lower end of the humerus protruded through the skin, lacerating the brachial artery and tearing off the insertion of the brachialis anticus muscle.

If the coronoid process remains on the trochlear surface of the humerus the dislocation is said to be incomplete; if it lies in the olecranon fossa of that bone it is said to be complete. In this latter event the appearance of the arm is characteristic, especially before swelling has supervened: the olecranon is prominent behind and is situated 3 or 4 cm. ($1\frac{1}{5}$ or $1\frac{3}{5}$ in.) above and posterior to its normal position; the triceps region is concave from the olecranon upward; the forearm is limited in extension and cannot be flexed to an angle of more than one hundred and twenty degrees with the humerus without the use of considerable force, perhaps enough to lacerate the posterior portions of the lateral ligaments; the joint is thicker antero-posteriorly than normally. By palpation the relatively high position of the olecranon is further made out, and the triceps may be pinched up and the hollow beneath it demonstrated; the sigmoid fossa of the ulna may also be felt in many cases; and, besides, the upper end of the radius is noted and the fact of its rotation is easily determined on making a similar movement of the forearm.

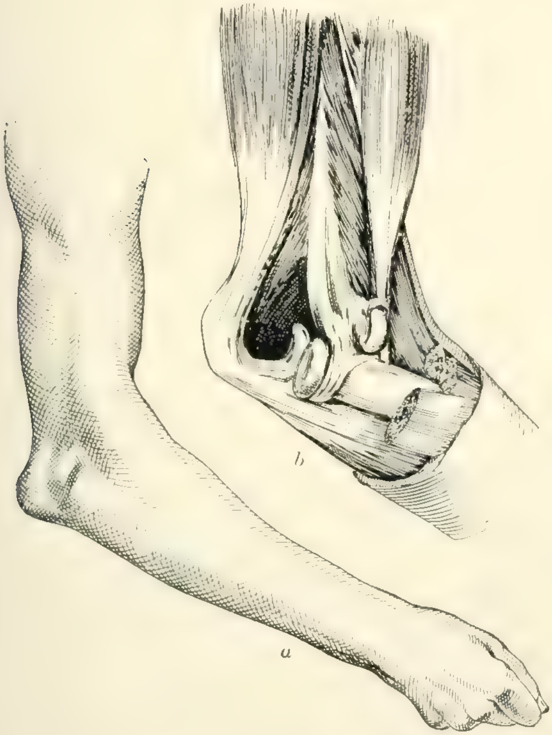

FIG. 26.—Dislocation of the Forearm Backward. (After Helferich.) *a*, External appearance of the dislocated forearm as seen in the living subject, the elbow being flexed to an obtuse angle, the olecranon projecting abnormally, and the rounded head of the radius being seen just beneath the skin; *b*, dissection of a dislocation artificially produced. Of particular interest in this picture is the condition of the annular and external lateral ligaments.

In backward dislocation the change is seldom purely a displacement backward; the bones of the forearm may be driven more or less outward or even inward, depending on just what portions of the ligamentous apparatus are torn. Furthermore, the broad contact of sigmoid and trochlea being lost and the ligaments being torn, lateral flexion movements of considerable degree are possible, and in fact the ulna would seem to be pivoted on the coronoid process in the olecranon fossa, owing to which condition, because of the weight of the forearm, internal rotation of the latter with reference to the humerus may take place, somewhat as occurs, though more freely, in supracondyloid fracture of the humerus and is there the chief factor in the production of the so-called "gun-stock" deformity.

In some cases of dislocation of both bones backward the anterior ligaments are ruptured above the orbicular ligament, but perhaps more often the orbicular ligament is torn from its attachment to the ulna at one or both ends. It may then fall into the joint and interfere with reduction.

It is not uncommon to have more or less of the coronoid process broken off by the violence of the thrust and the traction of tissues connected with the process. The fragment may be pulled quite a long distance upward by fibres of the brachialis anticus muscle when it is torn from its insertion. In some cases the fragment is a large one, in others it is scarcely to be made out in the Roentgen picture; but the fact that numbers of bone cells are carried upward is later made evident by the circumstance that, after reduction has been accomplished, an obstacle to flexion of the limb still persists,—an obstacle which has doubtless been created by the growth of these displaced bone cells.

Swelling and effusion of blood and later organization of the same, with development of new bone beneath stripped-up periosteum, may so obscure the findings on physical examination that the diagnosis becomes extremely difficult. The Roentgen picture is here most valuable, not only because it may determine the presence of a complicating fracture, but also because it may locate the fragments and fix their size, and may show the amount of new bone thrown out and its precise position;—in brief, it renders it possible to arrive at a correct decision as to reducibility.

In the absence of a Roentgen picture, in all but the simplest and most evident cases, an opinion should be reserved until an examination can be made under full anæsthesia.

Prognosis.—In nearly all backward dislocations reduction is easily made while the injury is yet recent, the exceptions being in case of some complicating fracture, especially a transverse or T-fracture of the lower end of the humerus, or a fracture of the external condyle, as well as in case of some peculiar form of laceration of the ligaments by which a large portion of the capsule may be interposed between the bones. Difficulty of reduction increases very rapidly, however, with time, so that at the end of two or three weeks but few complete dislocations of the elbow can be reduced, and these with great difficulty. Here the principal hinderance to reduction is the deposit of new bone beneath the stripped-up periosteum of the dorsum of the humerus. The cases reported where a dislocation of several months' duration has been successfully reduced are very exceptional and doubtless were simple cases with a minimum of damage done and the periosteum left practically intact.

In compound dislocation of the elbow the prognosis is not so unfavorable as might be supposed; with proper cleansing of the joint and reduction, to which end the opening may require to be enlarged, followed by drainage, a movable joint will be secured in a considerable proportion of cases. Wounded vessels should be ligated and divided nerves sutured. In case of failure of union of nerves, due to suppuration or other cause, secondary suture will often give nearly complete restoration of function.

In case of suppuration the joint should be widely opened without delay, efficiently drained, properly placed, and retained in a fixed position.

Treatment.—Moderate traction of the previously flexed forearm, with direct pressure on the olecranon, will reduce many recent dislocations; otherwise the method of Roser, which has practically superseded all other methods, should be used, preferably under complete anæsthesia. In Roser's method, the patient lying on his back, the humerus is fixed, preferably at the edge of the table. The operator then forcibly hyperextends the elbow to free the unfractured coronoid process from the olecranon fossa, and, without flexion, makes longitudinal traction on the forearm, with the view of drawing the coronoid process down over the trochlea. Then, continuing the traction, he flexes the forearm, when the coronoid glides into place and reduction is accomplished. There are two words of caution here necessary, however. In making hyperextension considerable force may be required, but it should be under perfect control; else, from the giving way of some untorn portion of ligament, the resistance may suddenly be relieved and excessive hyperextension result, jeopardizing the vessels in front of the elbow. Secondly, flexion should not be made until the coronoid is well down, else it will impinge on the trochlear surface and impair the cartilages and perhaps the cancellous bone of the lower end of the humerus. If it be found difficult to reduce the head of the radius, much can be gained by direct longitudinal pressure on its upper end and by lateral flexion inward (adduction); rotation of the forearm inward, with pronation, may materially assist.

The method of flexion about a pillar or about the knee or the forearm of the operator is far older than the method by extension, but is inferior to it. Doubtless Cooper's method is the best of the methods by flexion. The patient sits while the operator stands in front with his foot on the chair beside him. Grasping the arm with one hand and the wrist with the other, the operator makes strong traction, bending the elbow around his knee. Of course a limited degree of extension is exercised by this plan.

The arm should be put up at right angles or in still greater flexion in case of fracture of the coronoid process, to avoid recurrence of the dislocation and to favor approximation of the fragment.

Lateral Dislocations.—Dislocations of both bones of the forearm laterally are rare except in children, where they may be mistaken for fractures. Dislocation outward is much more common than inward probably because of the high ridge of the inner edge of the trochlea and the greater length of the internal condyle, and also perhaps because the direction of the violence militates against internal displacement.

The mechanism of the production of lateral dislocation of the elbow is not definitely known, but it would appear that it may be caused in a variety of ways: by direct violence, as by falls on the partially flexed elbow producing rotation; as the result of the complicated movements that occur in machinery accidents; and also as the result of indirect violence, as in falls on the outstretched hands. Some have thought that lateral dislocation more generally occurs as a result of hyperextension, as does backward dislocation, the lateral displacement being derived from the backward as a secondary position by means of lateral flexion; or else that it is produced by lateral flexion or rotation occurring at the moment of dislocation. Adduction and abduction, with the limb in partial flexion while the humerus is fixed, probably account for some cases, the former producing outward dislocation, the latter inward.

In the somewhat rare cases of complete lateral dislocation outward, the deformity produced by the projection, immediately beneath the skin, of the lower end of the humerus, and the prominence of the upper ends of the radius and ulna on the side of the humerus, make the diagnosis evident.

Much more commonly the dislocation is incomplete, the greater sigmoid cavity of the ulna resting on the capitellum. The elbow is wider than normally and the forearm is held in pronation or supination according to the position of the head of the radius. This latter is generally prominent beneath the skin, but may be obscured by swelling. The internal epicondyle is sharply prominent unless broken off, when it may fall into the joint and interfere with reduction. The ulnar nerve may be injured, and perhaps the posterior interosseous nerve also. Backward and outward dislocation is rather to be considered a variety of the backward than of the outward.

Inward Dislocations.—Complete inward dislocation of both bones does not occur. In partial dislocations the greater sigmoid cavity of the ulna rests on the internal condyle, obscuring it. The external condyle is prominent, and the head of the radius is missing from in front of it and will be found resting on the trochlea. Because of the difference in level of the trochlea and the internal condyle there are apt to be more or less adduction at the elbow and internal rotation. The forearm is pronated.

Divergent Dislocation.—Divergent dislocations are very rare (16 cases recorded, 14 antero-posterior and 2 lateral, Stimson). The pathology and symptoms are little different from the combined pathology and symptoms of isolated dislocations of the two bones. The internal lateral ligament is torn, the interosseous membrane is more or less torn, and the orbicular ligament is torn or loosened from one or both of its ulnar attachments. The humerus is driven between the two bones, the elbow is markedly flexed, and the forearm is rotated inward.

Dislocation of the ulna backward and of the radius forward can only be the result of great violence that tears the ligaments widely, especially the orbicular ligament, and permits the radius to leave the ulna. The forearm is held rigidly in a somewhat extended position midway between pronation and supination. There is adduction or rather rotation inward.

Treatment.—In general an attempt should be made to reproduce, or rather to reverse, the mechanism of production of the dislocation as most likely to lead to successful reduction, traction and adduction being made in case of a dislocation outward and abduction in case of one inward. Lateral pressure on the opposed parts will aid materially in reposition of a dislocation outward. The dislocation may be attacked as if it were a dislocation backward, and reduced by the same manœuvres which are suitable for that, assistance being afforded by direct pressure in the desired direction. Sometimes it is advisable to reduce one bone first and then the other.

Reduction is to be made, first of the ulna by the method of extension, then of the radius by extension of the forearm and supination, and by direct pressure on the upper portion of the radius.

Dislocations Forward.—These are rare, but occur more frequently without than with fracture of the olecranon. Scarcely twenty-five cases have yet been recorded (Stimson) and seven of these were with fracture of the olecranon, and as far as known they were caused by blows on the tip of the flexed elbow. And yet, from experiments on the cadaver it is admitted that circumduction of the forearm about the axis of the humerus, or great supination, the elbow being sharply flexed and finally extended, may bring the olecranon outward and forward on the anterior surface of the trochlea, when extension will force the olecranon upward. The injury is always a severe one and is accompanied by a rupture of the internal lateral ligaments and more or less of the outer. In the majority of cases of dislocations forward a blow on the tip of the strongly flexed elbow appears to have been the causative agent.

Two clinical varieties are described: one where the tip of the olecranon rests on the trochlea and the other where the dorsum of the olecranon rests on the anterior surface of the humerus. In the first the forearm is sharply flexed, in the second much less so. In the first the antero-posterior diameter of the lower part of the arm is increased, the olecranon fossa is palpable when the olecranon is not broken off and left *in situ*, and the elbow is blunt instead of being pointed. In the second form the coronoid and the sigmoid fossa are palpable in front, and the tip of the olecranon may be felt immediately beneath the skin.

If the olecranon is broken off and remains in the olecranon fossa it preserves the sharp point of the elbow and can be felt movable beneath the skin. The arm is shortened, and in front of the arm the sharply prominent coronoid process may be felt, but of course not the olecranon. These cases are more properly to be described as fractures of the olecranon with forward dislocation as a complication.

Because of the severity of the injury and the extensive laceration of the ligaments, reduction is not apt to be difficult. The arm should be put up at a right angle, and passive motion made after ten days or two weeks. In case of fracture of the olecranon, unless satisfactory adjustment is obtained, the bone should be fastened in place by screw, wire, or kangaroo tendon. (See p. 139 of Vol. III.)

Isolated Dislocation of the Ulna.—Dislocation of the ulna alone occurs very rarely and then nearly always in a backward direction and as the result of lateral flexion of the extended arm inward. Dislocation of the ulna in any other direction would require such extensive separation of the interosseous ligaments as to be almost impossible. The forearm is of necessity rotated inward and there is more or less change of position of the head of the radius on the eminentia capitata. Depending on the extent of laceration of the orbicular ligament, the ulna is more or less free of the head of the radius and lies with the coronoid process on the posterior surface of the trochlea or in the olecranon fossa or immediately beneath the radius. The dislocation is more apt to be incomplete and of the first form.

The arm is held in more or less complete extension, is capable of supination and pronation, is rotated inward, and is held in lateral (ulnar) flexion inward. As measured from the internal epicondyle to the styloid the forearm is shortened on the ulnar side.

Reduction is best accomplished by hyperextension, supination, and abduction.

There is one recorded case (Loison's) of dislocation of the ulna inward, the sigmoid embracing the epitrochlea, and there are two of dislocation forward (Stimson's and Wight's) with tearing up of the anterior muscles of the arm and laceration of the internal lateral ligament.

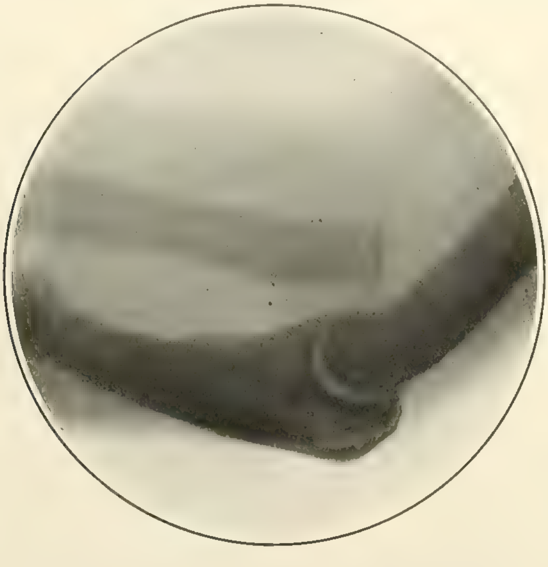

Fig. 27.—Upward Dislocation of the Radius, with Fracture of the Ulna, in an Adult. Side view. (Roentgen Department of Lane Hospital, San Francisco.)

Isolated Dislocation of the Radius (Figs. 27 and 28).—Dislocations of the radius alone are much more common than of the ulna alone. They are of four varieties: forward, backward, outward, and downward. The last occurs only in children and is sometimes called dislocation by elongation,—probably better described as diastasis.

Dislocation of the radius forward is the most frequent of these and is the result of internal lateral flexion (adduction) and forced pronation, the forearm being in the position of partial flexion. Clinically, it occurs in falls on the hand. It is suggested that the crossing of the radius and ulna in pronation develops a fulcrum permitting the force exerted at the wrist to tear the orbicular ligament, but it should be remembered that in the muscled forearm no such contact takes place between the bones as occurs in the stripped skeleton, although the underlying opposition yet remains.

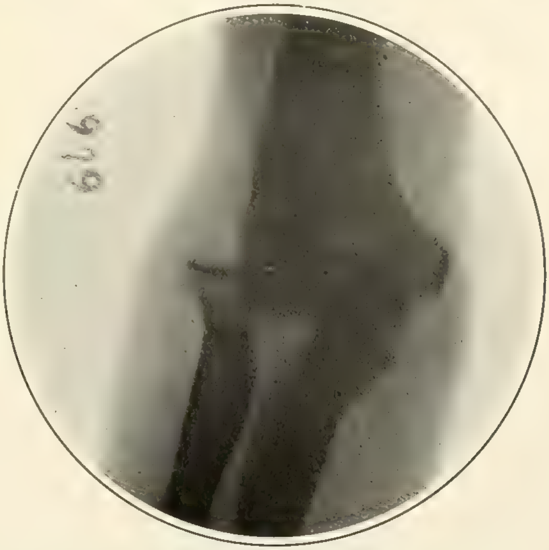

Fig. 28.—Antero-posterior View of the Case Shown in Fig. 26. (Roentgen Department of Lane Hospital, San Francisco.)

Generally the orbicular ligament is torn away from one or other of its ulnar attachments or is torn across above, but the head of the radius may be slipped out of the ring of the orbicular ligament by exaggerated adduction, with only minor damage to the latter.

Often there is concomitant fracture of the ulna at the junction of its upper and middle thirds. (See Fig. 27, taken from one of four cases seen by the writer, and Fig. 29.) Sometimes there is fracture of the head of the radius, or fracture of the internal condyle.

The symptoms depend somewhat on the degree of displacement of the head of the radius forward. If this is slight and the interosseous membrane is but little torn, the head of the radius impinging on the upper part of the external condyle prevents flexion of the forearm beyond a right angle. If the tearing of the ligaments is greater, the head of the radius may be sufficiently displaced upward, when the forearm is flexed, to pass over the upper border of the external condyle. In one case seen by the writer in a boy of twelve, in whom the dislocation and fracture of the ulna were some two years old, there were almost complete range of flexion and extension, and nearly perfect pronation and supination. In another an upward and outward bend of the upper part of the radius permitted the head of the radius to ride over the condyle. This was a very old dislocation, possibly congenital.

Ordinarily the forearm is held in abduction (internal condyle prominent) and in pronation. Lateral mobility is considerably increased.

Palpation shows the absence of the head of the radius in front of the internal condyle and its presence above in a rounded mass beneath the supinator longus muscle.

Treatment.—Reduction is generally to be effected by simple pressure on the head and upper part of the radius. Roser advises slight dorsal flexion (hyperextension) followed by flexion with direct pressure. In case the head of the bone has slipped out of the orbicular ligament the anterior capsule of the joint will be interposed between the head of the radius and the eminentia capitata. Because of the tearing of the orbicular ligament and interosseous ligament there is nothing to retain the head of the radius in place and the tendency to reluxation is very marked. Roser advises putting up the arm in acute flexion to prevent reluxation for a time.

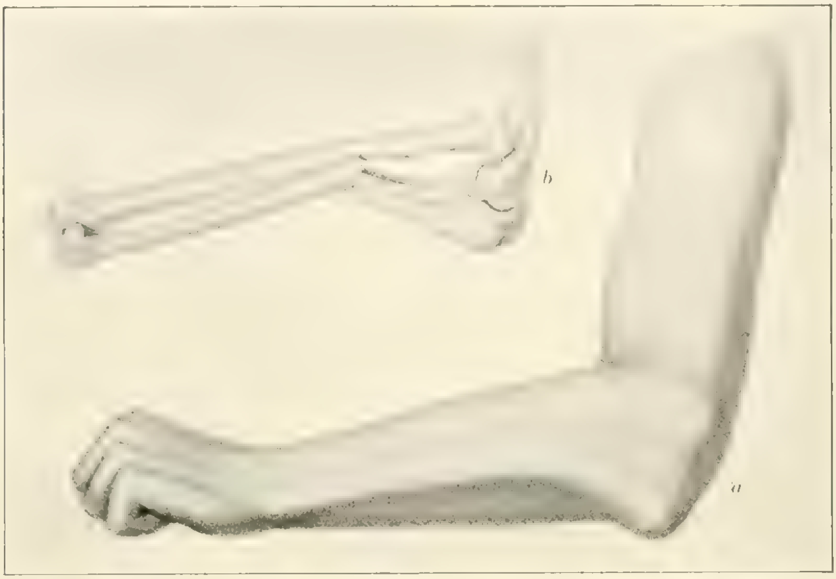

FIG. 29.—Displacement of the Head of the Radius Backward, and Fracture of the Ulna. (After Helferich.) *a*, Appearance presented by a forearm in which dislocation of the radius backward and fracture of the ulna had both occurred; *b*, dissection showing the relations of the radius, ulna, and humerus to one another in the case referred to above.

Concomitant fracture of the shaft of the ulna does not militate against reduction in recent cases. In these the forearm should be put up flexed at a right angle and between pronation and supination.

However, under the best of conditions the scar in the orbicular ligament, being weak, is apt to stretch under the traction of the biceps muscle in active flexion, and more or less complete luxation forward may result even long after an apparent cure.

In old unreduced dislocation and where reduction is either not possible or is not efficiently maintained, resort may be had to operation. Simple excision of the head of the radius will permit flexion of the forearm, and pronation and supination, but in suitable cases the orbicular ligament may be sutured. In the case shown in Fig. 30, an old anterior dislocation of the radius with fracture of the ulna, the writer was enabled, after opening the joint and dissecting out a fibrous mass from the lesser sigmoid fossa, to replace the head of the radius. The orbicular ligament being very largely destroyed (there was not enough of it left to reach around the neck of the radius), a flap from the anterior portion of the capsule of the joint was passed around the head of the radius and sutured to the periosteum and aponeurotic insertions on the outer side of the ulna. At the end of a year no reluxation had occurred, although the patient had been engaged in manual work, and this in spite of the fact that non-union of the ulnar fracture persisted. The elbow could be flexed to an angle of sixty degrees with the humerus and extended to about one hundred and sixty-five degrees, while rotation was completely restored.

Without operation the prognosis as to function is not altogether unfavorable, for if the head of the radius be lifted high enough it will permit of flexion by passing over the external condyle. In young children the radius bends outward and upward, lessening the resistance to supination. In two cases seen by the writer, of old unreduced anterior dislocation of the head of the radius in boys of ten and twelve, there were complete flexion and pronation and such slight limitation of supination and extension as to make operation unjustifiable.

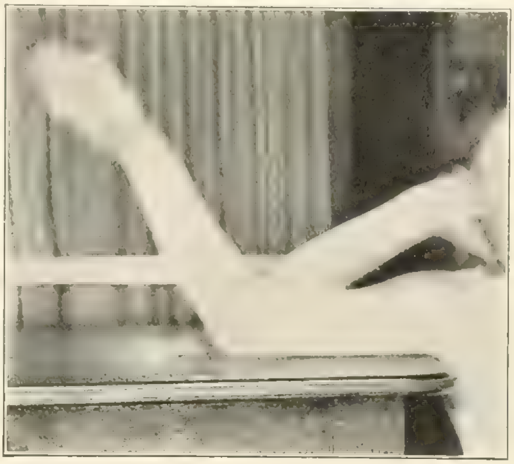

FIG. 30.—Two Exposures on the Same Plate, Showing Range of Flexion and Extension in an Old Unreduced Anterior Dislocation of the Radius, in which the head of the Radius rides over the external condyle. (Original.)

DISLOCATIONS OF THE RADIUS BACKWARD.—Less common than dislocations of the radius forward are dislocations backward. They occur in young people. A blow in front of the upper portion of the radius might be expected to cause this dislocation, but the great protection due to the depth of the radius beneath the supinator and extensor muscles at this point makes this unlikely. Most cases clinically give a history of falling on the outstretched hand as in dislocation forward, but probably in supination or, what is nearly the same thing, in the fall, the humerus is rotated inward on the fixed forearm.

The deformity is characteristic: the forearm is held in mid-flexion, in moderate pronation, and can neither be flexed nor extended nor supinated. The lateral angle at the elbow is exaggerated; *i.e.*, the radial side of the arm is shortened and the forearm is rotated outward on the humerus. The internal epicondyle is prominent and the head of the radius is felt beneath the capitellum.

Treatment.—Reduction is to be effected through traction with extension and supination, direct pressure being made at the same time on the head of the radius.

Dislocations of the Radius Outward.—Dislocation of the radius outward is rare enough to be looked upon as a surgical curiosity. Schroter collected some ten cases from the literature, but Stimson says that, if the cases with fracture of the ulna are excluded, not more than one or two have been reported. There are opportunities for difference of opinion as to the exact position of the radius in a given case, and it is a very nice distinction to say just which case is a purely lateral dislocation and which an outward and forward or an outward and backward.

With outward displacement of the radius the interosseous membrane is tensely stretched if not partly torn and the forearm is held midway between pronation and supination.

The cases which complicate fracture of the upper part of the ulna are said to be due to direct pressure outward of the fragments of the ulna at the point of fracture, or rather this point may be considered a fulcrum on which the radius rotates as a lever in adduction.

Treatment.—Reduction is not difficult, in fresh cases, by extension, supination, and direct pressure on the head of the radius. Adduction may assist, and in old cases open operation has succeeded.

Dislocations of the Radius Downward.—Dislocation of the radius downward, or diastasis, according to the accumulation of evidence, is the explanation of the injury which has frequently been found in young children, generally under four and almost invariably under six years of age. The diastasis is produced by simple traction on the wrist or perhaps with an additional lateral component of force (adduction) due to swinging the child. The head of the radius, at least its anterior edge, is pulled out of the ring of the orbicular ligament, by the traction and adduction. Supination increases the lateral angle between humerus and radius, and therefore increases the effect of the longitudinal traction.

The arm is immediately painful at both wrist and elbow and is held in pronation. The most characteristic feature is the inability to perform supination.

Treatment.—In forcing supination, and sometimes by the aid of flexion and adduction, a snap is heard and the symptoms disappear. The head of the radius is dislodged from the anterior edge of the annular ligament and, passing upward within it, takes its normal position on the capitellum.

Old Unreduced Dislocations.—As said above, the difficulties of reduction increase very rapidly with the lapse of time after dislocation, because of adhesions, the result of organization of inflammatory tissues, and of the growth of new bone from stripped-up periosteum or from bony fragments, the result of complicating fracture. Muscular retraction is of some influence, but is overcome without great difficulty unless time enough has elapsed for definite contracture to take place. Obstruction to reduction on the side of the soft parts may be more often overcome by breaking up of adhesions and stretching of scars, and dislocations presenting obstructions to reduction only of this sort can be reduced even after a long time. Still, occasionally shortened bands and muscles will require to be cut before reduction is possible.

Before any effort is made at reduction of an elbow dislocation of more than a very few weeks' duration, and still more so if unsuccessful attempts at reduction have previously been made, an *x*-ray picture should be secured, by which means much will be learned concerning the character of the obstruction. Often by this means the use of force with its many dangers will be avoided. By the use of force in hyperextension the ligaments in front of the joint may be torn off or the vessels injured, and in forced flexion there is great danger of fracture of the olecranon, or of damage of the trochlea by the coronoid process crushing into it.

Formerly, in refractory cases the only recourse was resection, or else forcing the joint into as nearly as possible the right-angled position and maintaining it there, by which a comparatively useful arm would be secured.

Resection may be expected to give excellent range of flexion and extension, although the power or force capable of being exerted in extension is deficient. Frequently the hand cannot be raised above the head, and there are decided deformity and increased lateral mobility. Still, the arm, having good power and range of flexion, is quite generally accepted as being more useful than when the elbow is stiff and set at a right angle.

In recent years the operation of reduction by open incision, when performed with perfect asepsis, has come to the front and gives a more nearly normal joint with moderate limitation of motion. Liston is said to have reduced such a dislocation after subcutaneous division of all tense bands, but modern work in this field dates from 1879 when Trendelenburg divided the olecranon, opening the joint widely, and dissected out fibrous tissue and newly formed bone, and, after reduction and final union of the olecranon, secured a movable joint.

The operation may be done through a single radial incision such as Kocher's incision for resection, or through bilateral incisions, according to the nature and position of the obstructions to reduction. Bunge (*Arch. f. klin. Chir.*, LX., p. 557) does not hesitate so to loosen up the parts as to cause the entire lower end of the humerus to protrude through the incision. Shortened bands and ligaments should be cut, fragments of bone removed, and new bone cut away; and fibrous masses should be peeled off the articular cartilages. It is important to injure the articular cartilages as little as possible. When reduction is accomplished, shortened tissues should be stretched by subsequent forcible movement of the joint. The arm should be put up in plaster of Paris at a right angle and passive motion be begun early, *i.e.*, after five or six days. Stimson has reported a number of cases successfully treated in this manner by him.

In case of failure to secure a movable joint, the operation of Murphy, of Chicago, of interposing a flap of fibrous and fatty tissue from the back of the arm between the bones (see *Jour. of Amer. Med. Asso.*, XLIV., 1905), will often secure useful mobility. The operation of Murphy has undoubtedly won for itself a prominent position, but the final judgment as to its superiority over resection cannot be said to have been reached as yet.

Dislocation of the Distal Radio-Ulnar Joint.—The relative movements of the head of the ulna and the lower end of the radius are determined to a large extent by the attachment of the triangular ligament or interosseous fibro-cartilage to the styloid process of the ulna, this latter being very near the axis about which the radius rotates in pronation and supination. This rotation is limited also by the interosseous membrane and, at the lower end of the bones, by the anterior and posterior radio-ulnar ligaments.

Except as a complication of fracture of the radius, particularly of the lower end in which frequently also the ulnar styloid is broken off, dislocation of the distal radio-ulnar joint is very rare. It is described as dislocation of the lower end of the ulna, probably because of the small size of that bone, but contrarily to the rule of classification, since the ulna is the more fixed of the two relatively to the remainder of the body. Dislocations backward and forward are described, the former due to excessive pronation, the other to excessive supination. In a case reported by Baum (*Zeit. f. Chir.*, LXVII.) a sharp blow on the lower end of the ulna produced a forward dislocation.

In dorsal dislocation the hand is held midway between pronation and supination; pronation is permitted, but supination is greatly limited. The transverse diameter of the lower part of the forearm is lessened and the antero-posterior increased, and the styloid rests on the dorsum of the radius. In volar dislocation the styloid is often broken off, but may be prominent on the flexor surface; pronation is limited.

Treatment.—In dorsal dislocation reduction is to be effected by supination and direct pressure, and in volar by pronation and direct pressure.

Diastasis of the Head of the Ulna.—Simple diastasis of the ulna occasionally occurs in consequence of fracture of the styloid and rupture or stretching of the radio-ulnar ligaments. Abnormal mobility of the head of the ulna is left.

Dislocations of the Wrist.—The wrist joint approaches very nearly the typical ball-and-socket joint, for the scaphoid and semilunar and cuneiform bones together make a rounded eminence comparable to the head of the femur or humerus, and which is sometimes called the "head of the hand." The shallow socket is composed of the articular surface of the radius and the lower surface of the triangular ligament. The chief motions permitted by the wrist joint proper are flexion and extension (dorsal flexion) and lateral abduction and adduction with but little rotation. Dorsal flexion and volar flexion are limited by contact of the carpal bones posteriorly and anteriorly on the edges of the articular surface of the radius, and to some extent also by tension of the anterior and posterior ligaments. So strong are these ligaments and so firm their attachments to the radius that excessive flexion in either direction is much more apt to result in fracture of the lower end of the radius than to tear off or rupture the ligaments, producing true dislocation of the carpus. In the earlier surgical literature these fractures were described as dislocations, but when their true nature was discovered the pendulum swung as far the other way and dislocation of the carpus was denied by many surgeons, among whom was no less an authority than Dupuytren.

Dislocation of the carpus does occur, however, both backward and forward, though perhaps more frequently in the former direction. The deformity resembles that of fracture of the lower end of the radius; but in recent cases, and if not too great swelling has occurred, the articular surface of the radius is to be made out by palpation. Extreme dorsal and volar flexion, combined with great force, causes these dislocations; the backward ones, as a rule, being caused by the latter factor, and the forward by the former. In dislocation backward the tendons are lifted off the posterior surface of the radius.

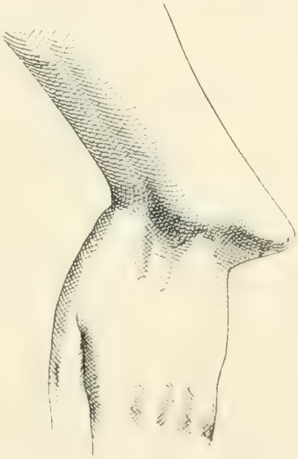
Fig. 31.—Deformity Resulting from Dislocation of the Carpus Forward.

Treatment.—Reduction is usually readily attained by means of traction on the hand, or by direct pressure on the displaced bones, or by both combined. Slight displacement forward is the tendency after reduction.

Compound dislocations of the wrist are the result of great force and are severe injuries. Couteaud (*Revue de Chir.*, XXVI., No. 8) collected seventeen cases (including two of his own) in which the mortality was fifteen per cent. Ankylosis was the general result and only exceptionally was motion of the fingers retained. Interference with nerve function, deformity and malposition of the hand, subluxation, etc., often resulted. The prognosis naturally depends on the degree of injury and on the character and intensity of infection. Couteaud advised prophylactic injections of anti-tetanic serum, cleansing and reposition, in most cases with drainage, but, in the presence of fracture, resection. In infected cases resection may be required secondarily. Passive motion and massage should be begun early. Amputation is seldom indicated; this on the ground that even a deformed hand is better than an artificial one.

A few cases have been reported of dislocation of the second row of carpal bones upon the dorsum of the first row with shortening of the hand and anteroposterior thickening, interfering with the motions of the fingers.

Dislocations of Individual Bones of the Carpus.—Individual bones of the carpus are occasionally dislocated and of these the most commonly dislocated is the semilunar. Eigenbrodt (*Bruns' Beitr.*, XXX.) collected 52 cases of which 27 were of the semilunar, 9 of the scaphoid (3 complicated with fracture of the scaphoid), 5 of the pisiform, 4 of the trapezoid, 4 of the trapezius, and 3 of the unciform.

Dislocation of the semilunar may be either forward, the result of dorsal flexion, or, less commonly, backward from volar flexion. The mechanism of the production of the dislocation of the semilunar is not clearly understood. Lesser (*Zeitschr. f. Chir.*, LXVII.) opposes the traction theory of Berger, the pressure theory of Potel, and the cherry-stone theory of Albertin, claiming that the dislocation is due to lever action and not to direct pressure or traction.

Dislocation of the semilunar may be complicated by fracture of the radius or of the scaphoid and in a large proportion of cases is compound (ten of the twenty-seven cases of Eigenbrodt).

Great swelling may obscure the projection of the bone in recent cases. There are more or less disability of the fingers and pain from pressure on the median or the ulnar nerve. The diagnosis, which may be difficult in individual cases, is made clear by a Roentgen picture, and, by taking profile as well as antero-posterior views, the position of the bone may be accurately determined and complicating fracture made out.

Reduction of the dislocation can seldom be accomplished even in recent cases, perhaps because of rotation of the bone, but reduction by open operation has succeeded in a few. In several, reluxation has occurred, requiring removal of the bone. In compound dislocation and in those cases in which reduction fails, extirpation should be performed and will give a useful wrist.

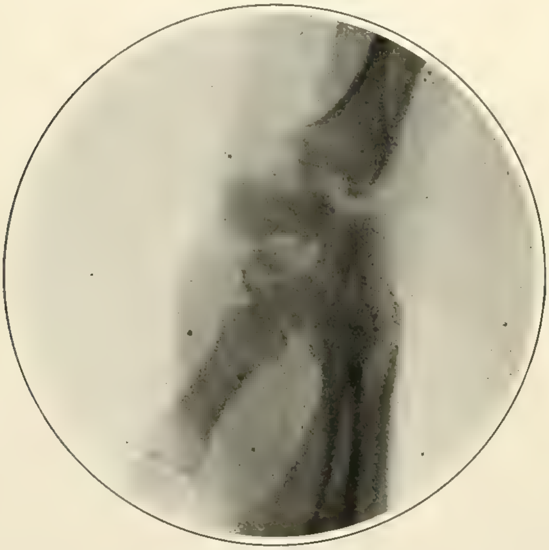

FIG. 32.—Dislocation of the Scaphoid Forward. (Roentgen Department of Lane Hospital, San Francisco.)

In a recent case of forward dislocation of the semilunar by Heygraves (*Lancet*, 1902, II.) there was a bony prominence in front of the wrist at the level of the radial styloid and a shortening of about one-fifth of an inch (0.5 cm.) as measured from the styloid processes. Pronation was possible, but supination was painful. Reduction was effected by traction and direct pressure. In a case of volar dislocation one year old, Urban (*Wien. med. Woch.*, 1903) excised the semilunar bone with relief of pain and restoration of motion, but because of lack of support the wrist was slightly displaced to the ulnar side and forward.

Dislocation of the scaphoid is usually forward and may be of the bone as a whole, in which case it is apt to be rotated to a right angle as in Fig. 32, but more frequently the bone is fractured and one fragment is displaced.

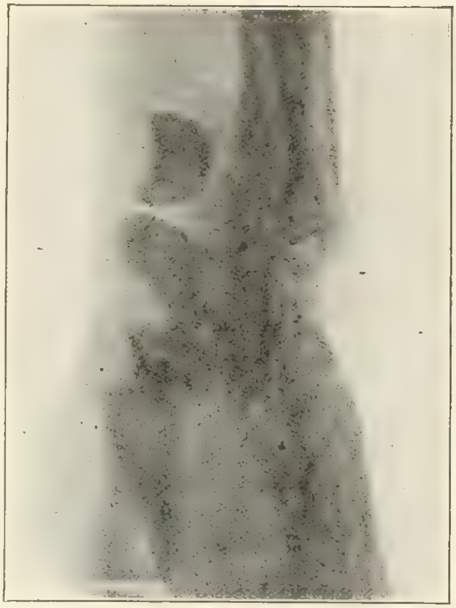

Fig. 33.—Dislocation of the Semilunar and Scaphoid. Profile view. (After Lejars.)

Dislocations of the metacarpal bones are less frequent than dislocations of the carpals and may be one or all of them forward or, which is more common, backward. The diagnosis is readily made, if the swelling is not too great, by the sharp prominence at the carpometacarpal joint. Complicating fracture is to be made out by the radiograph and by the presence of bony crepitus. Dislocation of the first metacarpal is more common than dislocation of the other metacarpals because of the greater exposure to trauma and its greater mobility.

Treatment.—Reduction is to be effected by traction and flexion in dorsal dislocation and by dorsal flexion together with direct pressure if the dislocation is volar. Except in the case of the first metacarpal, little disability results from the dislocation, though there is considerable deformity of the dorsum of the hand. (Fig. 34.)

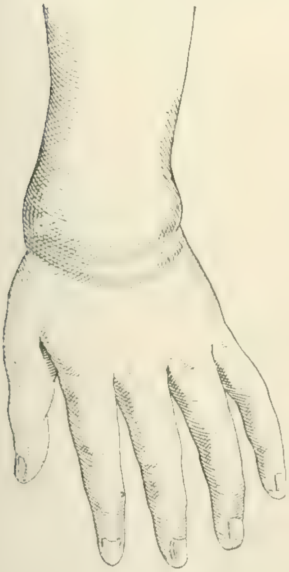

Fig. 34.—Deformity Caused by Dislocation of the Metacarpus Forward.

Dislocations of the Fingers.—The metacarpo-phalangeal and interphalangeal joints are allied to the arthrodial joints, but, as in the case of the wrist, they permit of a wide range of flexion and extension and—at least in the metacarpo-phalangeal joints—a smaller degree of lateral flexion. In the metacarpo-phalangeal joints there is very little rotation, in fact the rotation possible in these joints is due simply to laxity of ligaments: it is not a matter of muscular control, but is of use merely in a negative way as a safety factor in preventing injury. The interphalangeal joints permit of almost no lateral flexion and rotation.

All these joints present an important anatomical difference from the pure arthrodial joints in that the rounded bone of the joint or ball is on the proximal side and the glenoid or socket is on the distal, by which it happens that in complete dislocation the laceration of the capsule is on the side opposite to the displacement of the distal bone, quite the contrary of what occurs in such joints as the shoulder and hip. In other words, in dislocation of the finger joints the extremity of the bone on the proximal side, and not on the distal, passes through the rent in the capsule.

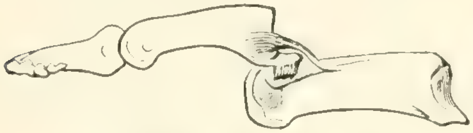

Fig. 35.—Relations of the Carpal Phalanges in a Complicated Dislocation of the Thumb. (After Farabeuf.) The sesamoid bone is pushed away from its natural position and is interposed between the phalanges.

The heads of the metacarpal bones are flattened laterally, so that their antero-posterior diameters are greater than the lateral, and the radius of curvature is correspondingly greater. The concave articular surface at the base of each one of the phalanges is wider laterally than that of the corresponding head of metacarpal or phalangeal, furnishing vantage points for insertion of strong lateral ligaments, etc., limiting the degree of lateral flexion and rotation, while antero-posteriorly the base of each phalangeal is smaller than the corresponding head, thereby permitting a large range of flexion (ninety degrees or more) and extension and some degree of dorsal flexion. Individuals differ greatly in the mobility of these joints.

Any of the metacarpo-phalangeal or interphalangeal joints may be dislocated, but because of its greater exposure to violence and its limited range of motion the metacarpo-phalangeal joint of the thumb is by far the most frequently dislocated. Nearly five per cent of all dislocations are of this joint (Hoffa).

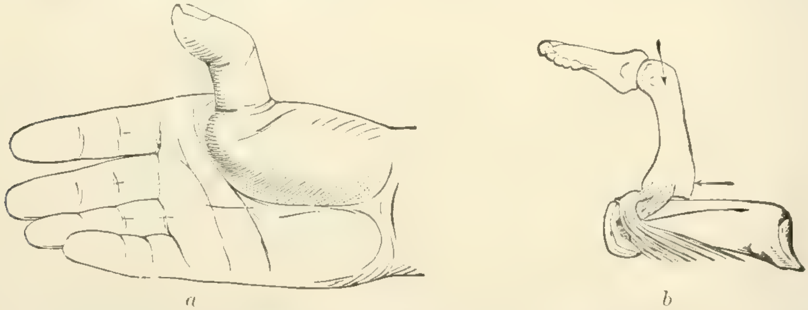

Fig. 36.—Simple Complete Dislocation of the Thumb. (After Farabeuf.) *a*, Deformity characterizing such dislocation; *b*, relations of the bones. The arrows show the directions in which pressure should be made in order to push the sesamoids to one side.

Dorsal, volar, radial, and ulnar dislocations of the first metacarpal joint have been described, but not only is the dorsal dislocation of the thumb the most common, but, from the very great difficulty met with in its reduction in many cases, it is of by far the greatest surgical importance.

Dorsal dislocation of the thumb is caused by excessive extension (dorsal flexion) and may be partial or complete. Many individuals, especially in childhood, can voluntarily hyperextend the thumb, producing partial dorsal dislocation, which they reduce by active flexion. In complete dislocation the anterior portion of the capsule is torn and the head of the metacarpal protrudes through it. The tendon of the long flexor is generally displaced to the inner side, so that the sesamoid bones lie on the inner side of the joint, and the inner one may reach the dorsum of the metacarpal. Primarily, the phalanx rests roughly at right angles to the metacarpal bone, with its articular surface in contact with the dorsal surface of the latter. Induced flexion (the active force may be a continuance of the original force effective on the base of the phalangeal, together with the resistance of the long flexor applied at the outer extremity) may cause the shaft of the phalangeal to become more or less parallel to the metacarpal, or partially flexed and in contact with it by its anterior surface. The terminal phalanx of the thumb is sharply flexed by reason of the tension of the long flexor.

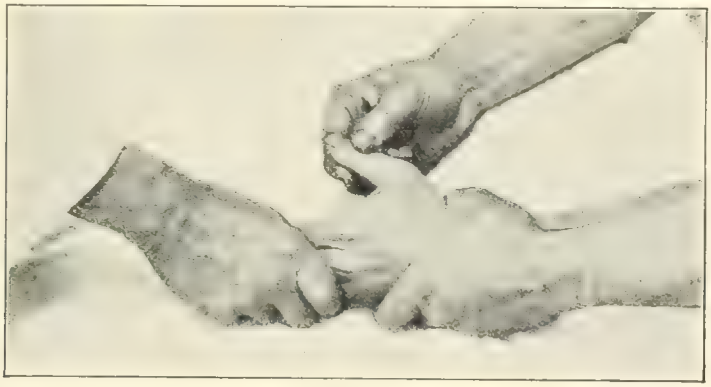

Fig. 37.—Reduction of a Complicated Dislocation of the Thumb. First step: traction in the axis of the thumb. (After Lejars.)

Treatment.—In some cases which may be classed rather as exceptions, reduction is readily effected by hyperextending the phalangeal till it is at right angles to the metacarpal and then flexing it after pressing it forward till its base passes over on to the articular surface of the metacarpal. In other cases reduction, except by open incision, is impossible. Many explanations have been offered for the difficulty of reducing this dislocation, and the sesamoid bones have borne perhaps more than their share of blame. It has been shown that the rent in the anterior portion of the capsule is apt to be nearer the volar than the dorsal end of the articular surface of the metacarpal; at least there is generally left a considerable portion of anterior capsule attached to the distal bone. When the dislocation is complete and the phalangeal is flexed so as to lie parallel to the metacarpal, this portion of the anterior capsule is carried past the rounded head of the metacarpal and, fitting closely around the neck of the bone, cannot be dislodged even though very great force be applied.

It has been found that in open operation, if this portion of the capsule is nicked, reduction is readily effected. Various devices for effecting reduction might be mentioned; such are, for example, special forceps, Leirs' lever, etc.

Since the phalanx is held in its position largely by tension of the short flexors, some degree of relaxation may be secured by flexing the metacarpal into the palm of the hand.

In case of serious difficulty in reduction, open incision is certainly preferable to traction with inordinate force, for the latter has in some instances done great damage; the thumb has been so injured as to slough, it has even been pulled off with its tendons. Stimson has suggested that section of that portion of the anterior capsule which is hooked over the end of the metacarpal may be made with a tenotome subcutaneously. In open arthrotomy, incision on the volar surface is advised.

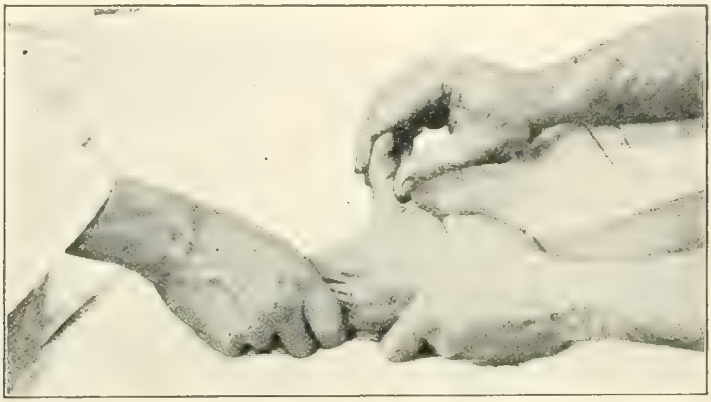

FIG. 38.—Reduction of a Complicated Dislocation of the Thumb. Second step. (After Lejars.)

Dislocation forward is much less common and is generally the result of a direct blow on the dorsal surface; simple flexion is seldom sufficient (Koenig), being resisted by the thenar mass. The dislocation is often more or less to the radial or to the ulnar side, rather than purely forward, and frequently more or less lateral flexion results because of the roundness of the volar extremity of the head of the metacarpal, as well as on account of axial rotation, pronation, or supination, according as the extensor aponeurosis is displaced to the radial or to the ulnar side. The base of the phalangeal is prominent in the palm and the rounded head of the metacarpal on the dorsum.

As a rule reduction is readily effected by flexion, traction, and extension.

Purely lateral dislocation may occur with laceration of the lateral ligaments of the opposite side. Reduction is to be made by a manœuvre similar to that used in reducing dorsal dislocation, viz., sliding the phalangeal downward as far as possible and then making adduction or abduction as the case may be.

After reduction, these dislocations may be retained best by a plaster-of-Paris spica of the thumb, but excellent fixation may be secured by strips of adhesive plaster laid on as in the turns of a spica. A short dorsal splint of pasteboard, yucca, or thin wood will give additional protection.

The interphalangeal joints permit of less lateral flexion and less rotation than the metacarpo-phalangeal. Functionally they are purely hinge joints.

Dislocations of any of these joints may occur—backward as the result of hyperextension, forward from hyperflexion, and laterally. The diagnosis in individual cases is evident on palpation, and reduction is readily to be made, in most cases, after the general manner already described for the reduction of dislocations of somewhat similar joints. However, occasionally an irreducible dislocation will be met with, requiring arthrotomy or even resection.

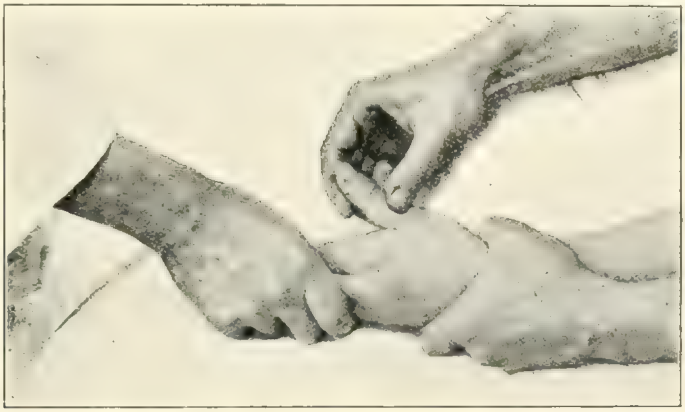

FIG. 39.—Reduction of a Complicated Dislocation of the Thumb. Third step. (After Lejars.)

Dislocations of the Hip.—The hip joint, more than any other of the principal joints of the body, is limited in its motions by muscular tension, which fact doubtless greatly lessens the frequency of dislocation as well as of fracture. On the cadaver the range of the various motions of the hip can be seen to be considerably greater when the muscles are removed.

When one considers the great exposure of the hip joint to severe force, the weight of the lower limb, the very long power arm of the lever of the thigh, and the very short weight arm (head and part of neck of the femur), one is struck with the singular infrequency of dislocation of the hip joint. It is difficult to determine the actual frequency relatively to the total number of dislocations, for different statistics vary all the way from two to twelve per cent. From the nature of the injury and its location the percentage in hospital statistics might be expected to be greater than in dispensary, and doubtless a much larger proportion of dislocations of the hip are reported than of many other joints, especially of the small joints.

No age is exempt from dislocation of the hip, but the greatest frequency would seem to be in middle life and in males. Doubtless the frequency in young children would be much greater if they were subjected to the same traumatisms as adults. In old age dislocation of the hip is rare because of the greater fragility of the bone, the relatively deeper acetabulum, and the comparative freedom from the kind of injuries which commonly produce dislocation.

About three-fourths of hip dislocations are posterior to the vertical plane passing through the centre of the acetabulum, but the occurrence of these secondary positions is no criterion for the determination of the relative frequency of the various primary displacements. The weight of the leg and thigh acting with such great leverage is sufficient alone notably to change the position of the head of the femur after it passes through the rent in the capsule.

Comparatively few cases of dislocation of the hip have come to autopsy in such wise as to determine the position of the rent in the capsule and thereby the point of the rim of the acetabulum where the head of the femur passed over. There is evidence, however, that the rent in the capsule may be at almost any point, although it naturally might be expected to avoid the region of great thickening of the capsule known as the ilio-femoral Y-ligament or Bertin's ligament. The fact that this band is rarely torn has long been known, but to Bigelow is due the credit of demonstrating its importance in relation to dislocation, in the determination of secondary positions, and in the manœuvres looking to reduction. The thinnest and therefore weakest part of the capsule is its lower portion, and here too the rim of the acetabulum is absent. The opposite or upper and posterior portion of the rim of the acetabulum, being highest, most readily offers bony resistance and in certain positions of the thigh forms a fulcrum whereby the head of the femur is forced out through the lower or weaker portion of the capsule.

The rent in the capsule may be of various forms, from a simple longitudinal slit to a total transverse tearing off of the capsule from the acetabular rim or from the neck of the femur. The most common form is a triangular rent with the lower portion of the acetabulum for the base, and the neck of the femur for the apex. The untorn portions of the capsule are not likely to present any considerable resistance to reduction in recent dislocations, except in those cases where the capsule is torn completely across and the portion attached to the os innominatum is folded across the acetabulum. From the manner of production of such rents in the capsule transverse tears are nearly always near the edge of the acetabulum and therefore not likely to leave fragments long enough to fold into the joint.

Dislocation of the hip occurs clinically for the most part by leverage, in the exaggeration of certain normal movements of the joint, in which, after the resistance of the opposing muscles is overcome, bony contact ensues and a fulcrum is developed. Additional movement in the given direction then lifts the head of the femur out of the acetabulum and forces it out through the capsule on the opposite side.

Of the simple rotations in frontal and lateral planes, flexion, extension, adduction and abduction, the last is the only one in which a bony fulcrum is developed, and that only after the adductor muscles have been stretched or torn. Flexion, after being more or less arrested by contact of the thigh with the abdomen, may develop a fulcrum on the pubic bone, but as this is at a considerable distance from the head of the femur and, as the point of impact with the shaft is external to the joint, there is caused a certain degree of rotation inward, thereby lessening the leverage which might produce dislocation. Axial rotations much more than simple flexions bring about bony contact and hence play an important rôle in the production of dislocations. Especially is this true of rotation outward, because the plane of the rim of the acetabulum "looks" forward as well as downward, the rim being higher behind.

In different positions of the thigh, in the sense of flexion, both the range of axial rotation and the points of arrest vary. For example, in the position of complete extension rotation outward is limited by contact of the posterior portion of the neck of the femur with the rim of the acetabulum, but rotation inward is limited simply by tension of the posterior portions of the capsule (ischio-femoral ligament). On the other hand, with the thigh in full flexion, rotation outward is limited by tension of the upper and posterior portions of the capsule, and rotation inward by contact of the anterior portion of the neck of the femur with the rim of the acetabulum. Similarly, with adduction no bony fulcrum is developed as long as the thigh is extended, but when it is flexed adduction may develop a fulcrum on the pubic bone. Thus, with the thigh in extension, abduction and rotation outward favor dislocation forward by developing a fulcrum posteriorly, while in flexion adduction and rotation inward favor dislocation downward or backward for the same reason.

The fulcrum may sometimes be the ilio-femoral ligament, as when the flexed thigh is strongly rotated outward. The ligament is tightly wrapped around the neck of the femur and furnishes a fixed point about which the head of the femur is forced upward and outward through the upper part of the capsule.

The study of dislocations of the femur has been retarded by the difficulties met with in producing dislocations on the cadaver. Until Allis showed that the fault lay in ineffective fixation of the pelvis efforts in this direction had failed, except where preceded by section of the capsule. Allis, after fixing the pelvis, was enabled to produce dislocation by simple abduction and by other manipulations, using the above described principles of leverage. He called attention to the fact that the forces causing dislocation clinically are severe and generally sudden, and that the inertia of the pelvis and rest of the trunk furnishes the relative fixity of the pelvis in the production of traumatic dislocations.

Longitudinal thrust is often combined with exaggerated movement of the hip and, notwithstanding the prominence given to leverage in modern theories, is probably not infrequently the more important active force leading to dislocation. This is the case in falls forward on the flexed knee, the thigh being flexed and adducted. Experiments on the cadaver (Allis) show that dislocation of the hip can be easily produced by making a longitudinal thrust on the flexed, adducted and inwardly rotated thigh. Allis is of the opinion that a very large proportion of cases of backward as well as forward dislocations are produced secondarily by extension of the thigh after the head of the bone has been forced out of the acetabulum through the cotyloid notch or at least over the lower part of the rim of the acetabulum. Certainly the success of the common manœuvres for reducing dislocations tends strongly to establish this idea as fact.

Direct violence applied to the trochanter doubtless accounts for some exceptional cases and is particularly effective when the blow is from above or behind and the thigh is abducted, for then there is little resistance to the passage of the head of the femur out through the cotyloid notch or over the lower portion of the acetabular rim.

Dislocations of the hip are always severe injuries the result of great force, and, since this may not all be expended in rupture of the capsule, much damage may be done the neighboring structures. The ligamentum teres is practically always torn apart, and the fibro-cartilaginous rim may be torn off more or less completely. The obturator muscles, gemelli, and pyriformis are frequently torn. When these muscles are not torn the stronger ones play an important rôle in determining the position of the limb. Bigelow considered especially the obturator internus in this regard, as its outer portion is largely tendinous and very strong. The head of the femur may escape "below the tendon" and be forced up behind it. If at the same time the leg happens to be extended, making tense the hamstring muscles, the head of the femur is forced backward, causing the sciatic nerve to be bent sharply about the neck of the femur. If the thigh is then adducted and brought down, perhaps with some outward rotation, producing a reversed dorsal dislocation, the head of the bone may pass upward behind the sciatic nerve. The very opposite complication may arise and is likely to be the more common when, in a dorsal dislocation, the head of the femur is brought down, perhaps in the manipulation of reduction, and made to pass from behind forward around and beneath the sciatic nerve. This occurred in a case seen by Koons, of Philadelphia, and quoted by Allis. In a case in the practice of the writer, a powerful young man had been swept many times around a rapidly revolving shaft, his whole body passing through a space of nine inches. He sustained a dislocation of the right hip, dislocation of both knees, and fracture of one tibia. The right sciatic nerve was paralyzed as well as the left peroneal. Reduction was made without difficulty by Kocher's method, the head of the bone slipping into the acetabulum, but the thigh could not be extended beyond the position of one hundred and thirty-five degrees (forty-five degrees of flexion). The obstruction was probably the sciatic nerve, for, after reluxating and making flexion, adduction, and then external rotation, no difficulty was experienced in reducing the dislocation a second time by the manipulation of Kocher, and this time there was no impediment to extension. At present, one year after date of the accident, there is still nearly complete sciatic paralysis.

In machinery accidents where movements of circumduction have taken place, the capsule may be wrapped around the neck of the femur or it may be torn completely off. Similarly, the sciatic nerve may be wrapped around the neck of the femur or be crushed or torn *in loco* or within the pelvis, and may be severely crushed by being pinched between the head of the femur and the edge of the sacrum in ischiatic dislocation.

In a few cases (9, Stimson) dislocation of the hip has been compound. They were all cases of great violence, about evenly divided between forward dislocations and backward dislocations, several of them the result of direct violence. Seven of the nine died, five as a result of associated injuries, two of sepsis. In several the head of the femur was excised, but in recent cases Stimson is inclined to think the removal of the head unnecessary.

Many classifications of dislocations of the hip have been suggested; some consider only the position of rest of the femur while others take into account the position of the rent in the capsule. The classifications of several authorities are given below:—

BIGELOW.

1, Dorsal high.
2, Dorsal below the tendon.
3, Thyroid.
4, Pubic and subspinous.
5, Anterior oblique.
6, Supraspinous.
7, Everted dorsal.

ALLIS.

1, Thyroid or inward.
  a, low.
  b, middle.
  c, high.
  d, reversed.
2, Dorsal or outward.
  a, low.
  b, high.
  c, reversed.

KOENIG AND LOSSEN.

1, Backward (iliac and ischiatic).
2, Forward (suprapubic and infrapubic).
3, Supracotyloid.
4, Infracotyloid.

STIMSON.

- Backward . . . .
  - dorsal
    - iliac.
    - ischiatic.
  - everted dorsal.
- Downward and inward
  - obturator.
  - perineal.
- Forward and upward (suprapubic)
  - ilio-pectineal.
  - pubic.
  - intrapelvic.
- Upward (supracotyloid or subspinous).
- Downward on tuberosity of ischium.

It would seem that the classification of Allis has some advantages, at least as regards simplicity and because the primary divisions are determined by a natural distinction between the anterior or inner and the posterior or outer surfaces of the os innominatum, which are, roughly speaking, planes intersecting on the line passing through the anterior superior spine of the ilium and the centre of the acetabulum. The purely upward and downward dislocations are omitted from Allis's classification. If the head of the femur comes to rest on the line joining the anterior superior spine of the ilium with the centre of the acetabulum above or below, it is in more or less unstable equilibrium and may be displaced by slight rotary force. Practically all the cases can be described, so far as any clinical purpose is concerned, as high or low forward or backward dislocations, more particularly so when by this means can be indicated, more or less accurately, the relation to the primary positions. It is important, with reference to means of reduction, to note that a primary forward dislocation may be transformed into a backward, and *vice versa.*

By "reversed dorsal" dislocation Allis would designate Bigelow's "everted dorsal" and by "reversed thyroid" a forward dislocation which has undergone so great a degree of rotation outward that the head of the femur has passed upward over the pubic bone and lies anywhere from the inguinal region to the dorsum of the ilium.

DISLOCATIONS BACKWARD.—Dislocations of the femur backward are most often the result of flexion and adduction with more or less rotation inward, perhaps with added thrust. The point of laceration of the capsule depends somewhat on the degree of flexion; the more complete the flexion the lower the rent. With maximum flexion the head of the bone is apt to pass into the sciatic notch. The total range of positions which the head of the femur may occupy is less than is commonly supposed, being only from about the level of the spine of the ischium to near the summit of the great sciatic notch.

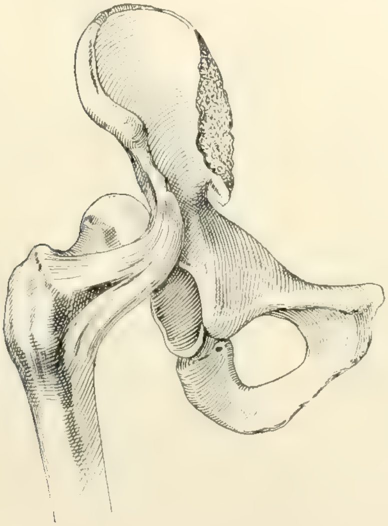

FIG. 40.—Dislocation of the Head of the Femur on to the Ilium. (After Helferich.)

The characteristic deformity of rotation inward is dependent on the persistence of the outer portion of the ilio-femoral ligament. If this is torn the rotation inward disappears. The thigh is held in elastic tension, is adducted and more or less flexed, the ball of the foot commonly resting on the dorsum of the opposite foot. The lower the position of the head of the femur the greater the degree of flexion and the more marked the adduction, until, when the head rests on the ascending ramus of the ischium (infracotyloidean luxation), there is more or less abduction. The movements permitted are further flexion and adduction, but other motions are resisted.

Except in very low positions of the femur there is shortening, which in exaggerated cases may amount to as much as 4 or 5 cm. ($1\frac{3}{5}$ or 2 in.). The degree of shortening is difficult to estimate because of the adduction and flexion deformity, but for purposes of diagnosis is not of great importance. The trochanter lies above Nélaton's line, but because of the obliquity of this line the rotation inward lessens the height of the trochanter above it.

In not too fat subjects the head of the femur can be felt beneath the gluteal muscles, especially if the thigh be rotated back and forth, and its absence from the joint is manifested by lessened resistance to deep presssure in the groin as compared with the sound side.

In ischiatic luxations rotation inward is perhaps less marked than in iliac. The head of the femur is more difficult to be felt and the trochanter is little if at all above Nélaton's line. Flexion is greater and adduction generally so, but rotation inward is apt to be less marked than in iliac dislocations.

In the "reversed dorsal" dislocations the outer portion of the ilio-femoral ligament is quite sure to be torn, after which eversion may take place with little resistance. The head of the femur may lie as far forward as the anterior border of the ilium (subspinous dislocation), or even farther forward and higher (anterior oblique dislocation).

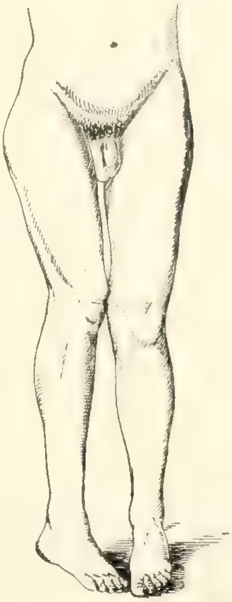

Fig. 41. — Dislocation of the Head of the Femur on to the Ilium. Position maintained by the affected limb when the patient is in a standing posture. (After Helferich.)

The symptoms may differ from those of the typical iliac dislocation only in the greater or less degree of rotation outward that may be present, but the head of the femur may pass far enough forward for the thigh to be extended and even somewhat abducted. In the latter case shortening is much more evident.

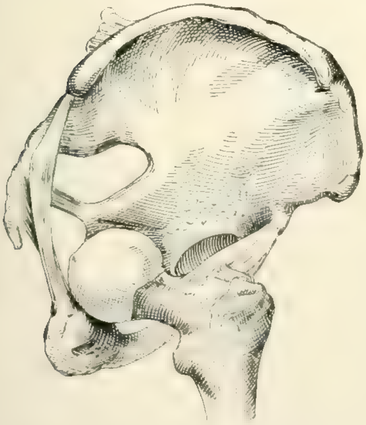

Fig. 42.—Dislocation of the Head of the Femur on to the Ischium. (After Helferich.)

In a case of infracotyloidean dislocation reported by Wendel (*Deut. Ztschr. f. Chir.*, LXXXI.) the head of the femur came to rest on the flat surface of the ischium just beneath the acetabulum, the diagnosis being verified by radiographs. The thigh was flexed forty-five degrees, abducted, and held in elastic tension midway between rotation outward and rotation inward. Wendel was able to collect fourteen similar cases from the literature.

Treatment.—Perhaps in the reduction of dislocation of the hip, more than in that of other joints, the advantages of general anæsthesia are manifest. Here the weight of the limb, the great power of the muscles, the tension of untorn portions of the capsule, the inflammation and pain consequent on the severity of the injury, all tend to make the operation of reduction a painful one. Involuntary as well as voluntary contraction of the muscles is inevitable and adds greatly to the difficulty of reduction.

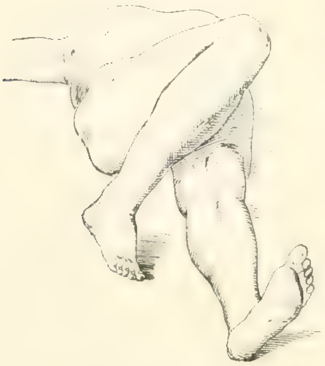

FIG. 43.—Dislocation of the Head of the Femur on to the Ischium. Position maintained by the affected limb, when the patient is in the recumbent posture. (After Helferich.)

Some dislocations, especially in children, can be reduced by longitudinal traction in moderate abduction, with manual lifting of the head of the femur over the rim of the acetabulum. But, as said above, surgery owes to Bigelow, of Boston, the principle of utilizing the untorn portion of the capsule as a fulcrum in the reduction of dislocation of the hip. From the nature of the case the portion of the capsule which is least frequently torn is the ilio-femoral ligament. Bigelow reduced backward dislocations of the hip by a process of circumduction, the flexed knee being forced in a direction opposite to that desired for the head of the femur; *i.e.*, the leg being flexed to a right angle to relax the hamstring muscles and to furnish an effective lever by which the thigh can be controlled, particularly in the matter of rotation, and grasped at ankle and upper calf, the thigh is flexed, rotated inward, and adducted and then circumducted inward, upward, and outward, the rotation inward being maintained. When by this means the head of the femur is brought down to approximately the point where it passed over the rim of the acetabulum, the thigh is rotated outward and extended. The ilio-femoral ligament is thereby made tense and great power is developed, tending to force the head of the femur upward over the rim of the acetabulum, which may be materially aided by an upward jerk of the bone, the pelvis of course being fixed. In the manipulations for reducing a dislocation of the hip it is well to remember that the inner aspect of the knee "looks" substantially in the same direction as the head of the femur. The rule, as more often laid down, is as follows:—Flex the leg on the thigh and the thigh on the pelvis to a right angle, maintaining the present rotation inward and abduction; raise the limb quickly upward, and then, if need be, employ abduction, outward rotation, and extension. When the limb is raised upward, reduction may ensue, especially if a beginning has been made to abduct the limb and to rotate it outward. If reduction does not follow, it is better to try again in the same manner, but with increased force, than to push the extension of the limb any farther; but, if reduction take place, then the limb, rotated outward, should be carried to the side of its fellow.

Bigelow's method of reducing backward dislocations of the hip has become classical, but it is still open to objections. One objection on mechanical grounds is that sufficient force has to be developed, by the rotation outward and extension, to force the head of the femur up an inclined plane, the line of traction on the fulcrum (the ilio-femoral ligament) lying nearly at right angles to this plane. Furthermore, with the patient lying on his back, the force required is still greater in order to overcome the weight of the limb.

More modern methods (Kocher, Allis) endeavor, by seeking a favorable position of the limb, to relax all the structures about the hip, and by traction in the axis of the thigh to overcome its weight.

The patient is placed on a low table or, preferably, directly on the floor, and the pelvis is fixed by the hands of assistants or (Allis) by bandages or swathes threaded through hooks screwed into the floor and passed around the pelvis. The thigh is then flexed, more or less adducted, and rotated inward to relax the capsule and the muscles, and traction is made forward, *i.e.*, directly upward from the floor. At this time traction downward and outward is of aid and may be made by an assistant pulling on a swathe passed about the upper part of the thigh. The degree of adduction, flexion, and rotation inward necessary will vary with individual cases according to the site and extent of the rent in the capsule, and a little careful study and search for the rent without the use of much force will be well rewarded.

Stimson places the patient face downward on a table with the injured thigh hanging off the end; flexes the leg to a right angle, where it is held until muscular relaxation ensues, when the head of the bone, without special aid other than that of slight rocking and rotation, goes into place. It may be necessary, however, to supplement the weight of the limb by that of a small sand bag placed at the knee or by downward pressure suddenly applied at the same place. Anæsthesia may not be required. Stimson has practised this method "for many years" with gratifying success. (Fig. 44.)

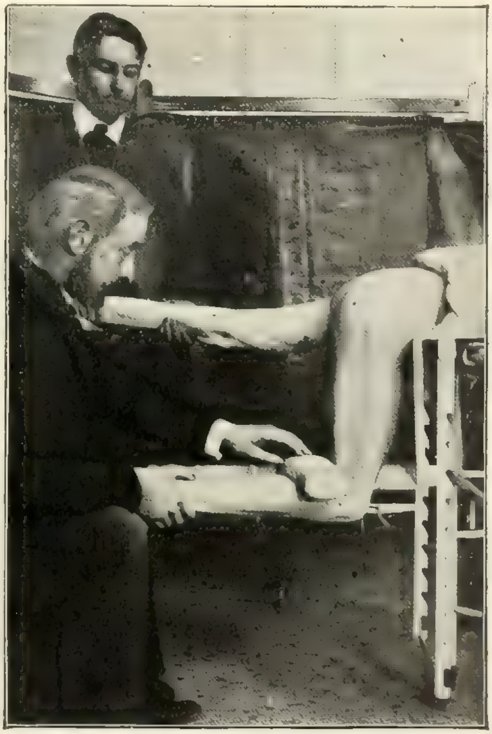

FIG. 44.—Stimson's Method of Reducing Dislocations of the Hip.

After reduction the patient should be kept in bed for two weeks or longer. If there is a manifest tendency to recurrence it should be combated by abduction and rotation outward, or perhaps better by fixation in a plaster-of-Paris spica. If there is fracture of the upper portion of the rim of the acetabulum, traction should be employed for some weeks.

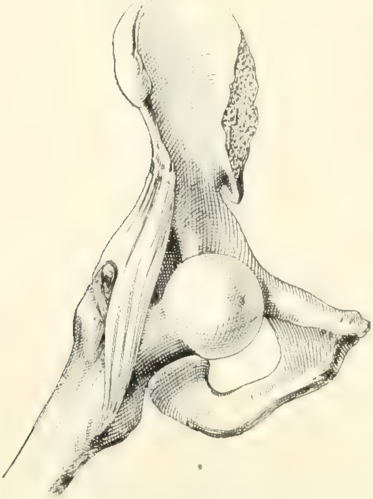

Fig. 45.—Dislocation of the Head of the Femur on to the Pubes. (After Helferich.)

Dislocations Forward.—From experiments on the cadaver and clinical observation, dislocation forward is apparently caused by excessive abduction in either flexion or extension, or by a blow from above and behind when the thigh is in abduction. It is about one-third as frequent as dislocation backward. In low anterior position of the head of the femur (luxatio obturatoria) the latter lies beneath the adductors and obturator externus and the trochanter nearly in the acetabulum. The limb is held in elastic tension by the spastic adductor muscles and the upper untorn parts of the capsule, especially the ilio-femoral ligament. Bigelow showed that the rotation outward is largely determined by the persistence of the inner portion of the ilio-femoral ligament. The thigh is flexed, abducted, and rotated outward. There is nearly always more or less shortening; though, as in dislocations backward, this is difficult to estimate accurately because of the difficulty of putting the two thighs into symmetrical positions; but, when they are thus placed, apparent lengthening may be found.

Since the length of a lower limb is measured from the anterior superior spine of the ilium to the inner malleolus, or, perhaps better, in the measurement of the femur to the adductor tubercle, it will be lessened by any movement of the femur upward in the plane passing through the three points—the anterior superior spine, the head of the femur, and the adductor tubercle, because thereby the angle between the axis of the femur and the line joining the head of the femur with the anterior superior spine is made less obtuse. The opposite movement will cause lengthening. When the head of the femur is in the acetabulum the plane mentioned is slightly oblique, being tilted outward, from which it follows that maximum shortening is produced by flexion with slight abduction. If the head of the femur be on the dorsum of the ilium this plane is very oblique, or even rotated ninety degrees, in which position

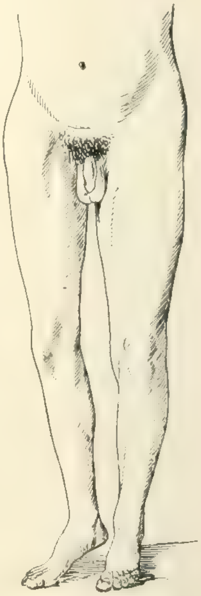

Fig. 46.—Dislocation of the Head of the Femur on to the Pubes. Position maintained by the affected limb when the patient is in a standing posture. (After Helferich.)

shortening is very marked. If the head be below and in front of the acetabulum as in thyroid dislocations, this plane is much more inclined outward, hence the maximum shortening will be found in flexion and abduction. Since this is the precise position of the thigh in thyroid dislocations, there is invariably shortening of the limb in all these dislocations. Adduction of the sound limb, however, so far compensates for the abduction of the dislocated limb as to make the two parallel, rendering evident thereby an apparent lengthening of the dislocated limb. This apparent lengthening, however, is less than would occur in a normal individual with the same degree of abduction.

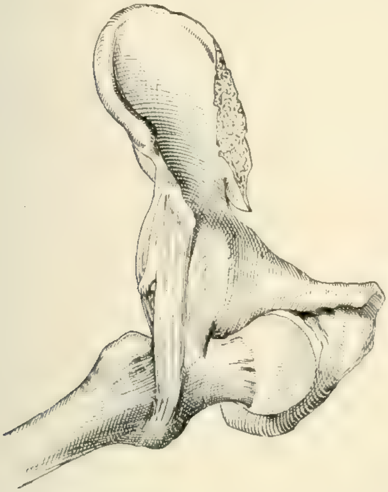

FIG. 47.—Dislocation of the Head of the Femur into the Obturator Foramen. (After Helferich.)

The head of the femur lying beneath the adductor muscles and being further resisted by the obturator membrane together with the ramus of the pubic bone in "low thyroid" dislocations, the weight-bearing function is retained and the patient can walk very much better than is possible in other dislocations of the hip.

In high forward dislocations the head of the femur finds less rigid resistance to upward thrust, and the ability of the patient to walk is correspondingly less. The thigh is relatively more movable and lies in lessening degrees of flexion and abduction, the higher the head. Rotation outward is always marked, and the head of the femur can be felt or even be located by the eye by the bulging in the groin. In a few cases the head of the femur has been known to slip beneath Poupart's ligament or tear it across and become hooked over the horizontal ramus of the pubic bone (intrapelvic dislocation). In this form of dislocation the thigh is extended, but is neither markedly abducted nor everted. The laceration of the capsule must be extreme to permit of such position of the head of the femur, and the position of the limb in the sense of rotation will be determined in particular cases by the portions of the capsule which remain intact.

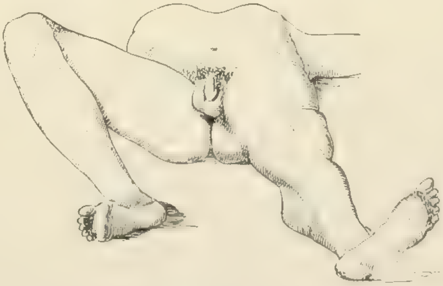

FIG. 48.—Dislocation of the Head of the Femur into the Obturator Foramen. Position maintained by the affected limb when the patient is in the recumbent posture. (After Helferich.)

In reversed thyroid dislocation the eversion may be so great that the foot points backward. As can be readily understood, the ilio-femoral ligament simply serves to keep the anterior portions of the neck of the femur at a constant distance from the pelvic attachment of the ligament. The thigh, being without other restraint, in this dislocation, is susceptible of a wide range of mobility.

In a few rare cases occurring with a high degree of flexion and probably also with forcible longitudinal thrust, the head of the femur passes internally to impinge upon the ascending ramus of the pubic bone or slips over it into the perineum. Perineal dislocation is accompanied with great laceration of the capsule and is to be looked upon as an exaggeration of a low thyroid or obturator dislocation. It is somewhat comparable to luxatio erecta in the shoulder. The thigh is strongly flexed and abducted. The head of the femur can be felt in the perineum. Most of the cases of compound dislocation of the hip are of this variety.

Treatment.—In general, forward (thyroid) dislocations of the hip are to be reduced by a manipulation very much the opposite of that used in backward dislocations. The thigh is flexed toward a perpendicular and abducted a little so as to free the head of the bone; it is then rotated strongly inward and afterward adducted, and the knee is carried to the floor. (Bigelow.) If, after the preceding adduction, the limb be rotated outward and immediately afterward circumducted outward, upward, and inward, then by extension and rotation inward reduction should be effected. Or the rule may be briefly stated as follows:—Flex the leg on the thigh and the thigh on the pelvis to a right angle, continuing the present abduction and outward rotation; make upward traction on the flexed limb and then afterward resort to abduction, outward rotation, and extension of the limb. As in backward dislocations, the particular position of the rent in the capsule is of practical importance, and painstaking search should be made to determine it. Care should be exercised not to carry out the above manipulation so literally as to force the head of the femur below and around the acetabulum, by which the forward dislocation will be transformed into a backward. When the head of the femur has been gotten into the position in which it left the acetabulum, traction may be made in the direction of the shaft of the femur and also outward and downward by a narrow swathe passed around the upper part of the flexed, abducted, and outwardly rotated thigh, by which the head may be lifted over the acetabular rim.

Allis, after fixing the pelvis to the floor, pulls the head of the femur outward above the acetabulum, fixes the head, pushes the knee of the injured side toward the sound one, and extends the femur.

Kocher flexes the thigh to a right angle with the pelvis, maintaining the abduction and outward rotation as found; after which he makes upward traction and then inward rotation, thus bringing the head of the bone into place.

If the rent in the capsule is high, as in ilio-pubic dislocation (Busch), inward rotation of the flexed thigh and outward lateral traction followed by adduction most nearly meet the indications.

Individual cases require special investigation to determine the primary position of the head of the femur, for the successful manipulation of reduction depends more on that than on the more varied secondary positions.

Other forms characterized by upward and forward and inward and forward displacement, especially the ileo-pectineal, pubic and intrapelvic kinds, can be reduced by various atypical manipulations: steady longitudinal and lateral or downward traction on the thigh as it is brought from a position of extension and abduction to one of flexion and adduction will meet the indications in some cases; moderate flexion, adduction, and traction downward will succeed in others.

Treatment.—The following is substantially Kocher's method of practice: Make longitudinal traction of the limb as it is found, to bring the head of the femur below the brim of the pelvis—this traction, if it fails, to be aided by increased extension, abduction, and outward rotation, thus rendering tense the posterior portion of the capsule and at the same time making its point of attachment the centre for the motions which should next be carried out. Place the hand upon the head of the femur to prevent its return upward as the thigh is flexed to less than a right angle to relax the Y-ligament. (Further flexion would bring undue strain on the posterior part of the capsule.) Sometimes reduction is thus effected, but rotation outward may be needed to secure the desired result.

Old Unreduced Dislocations.—It is not possible to lay down rules of very wide application in the treatment of old unreduced dislocations of the hip, for the variations of conditions presented by different cases are so great as to require that the indications for treatment be worked out for each case individually. In many cases a sort of new joint is eventually formed, especially in iliac dislocations, which gives a considerable range of motion with fair support. At the opposite extreme is complete bony ankylosis which, in case the position is not too bad, will give such useful supporting function as to contra-indicate operative treatment.

From the nature of the case the means required for reducing an old dislocation of the hip must be severe, and reduction is not to be undertaken unless well warranted by the suffering of the patient. The great force necessary for overcoming the shortening of the muscles, fascias, and ligaments, for tearing apart the healed rent in the capsule, which is apt to have contracted about the neck of the femur, and for breaking up old adhesions, is likely to do great damage. Vessels may be torn or lacerated in such wise as to cause obstruction to the blood supply to the limb and thus produce gangrene, or nerves may be lacerated or stretched sufficiently to cause paralysis, more or less permanent, and the bone may be fractured—the neck or head of the femur or the rim of the acetabulum.

On the other hand, reduction has been accomplished in reported cases as long as six months after dislocation, with complete restoration of function.

Sufficient loss of function to incapacitate the patient, severe pain from pressure of the head of the femur on some nerve (sciatic), severe and unsightly deformity from malposition, would be admitted by all as indicating operative treatment. The difficulty of decision will occur when the function, the suffering, and the deformity are less than this.

The choice of operative procedure lies between manipulative reduction, transposition of the head of the femur to some point more favorable for function, as in the Lorenz operation in congenital dislocation, reduction by open incision, and, finally, resection.

Manipulative reduction should not be attempted, at least with much force, except in fairly recent cases, and should be preceded by thorough breaking up of adhesions and stretching of contracted tissues. Sometimes it is of value to cut the adductors. Continuous traction by weight and pulley for some days may assist in lessening muscular resistance. In general, the same manipulation should be employed as described above for the corresponding acute dislocation. In case of fracture of the femur in the manipulation or previously, it is probably better to remove the head of the bone than to attempt to pull it into place and fasten it by nail or staple to the neck of the bone, but the surgeon should use his judgment in this matter when the joint is open, for if there be preserved some capsular attachment to the fragment, especially the fold of Amantini, fixation of the head by a nail or screw driven through the trochanter may succeed in bringing about bony union.

The dangers of open operation are chiefly those of infection. There are practical difficulties in the way of efficiently sterlizing a wide enough area about the site of operation, and even after contracted tissues are cut there is still required a great deal of manipulative force to get the head of the femur into the acetabulum, and, besides, the fingers are in the wound much of the time. If gloves are worn they are very likely to be torn.

Hoeflinger (Inaug. Diss., Bern, 1900) reported three cases and collected thirty-seven from the literature, of which twenty-four were subjected to arthrotomy and sixteen to resection. In two in which operative reduction had been performed, resection was subsequently required—in one for poor function, in the other for necrosis of the head of the femur. Hoeflinger concludes from a study of these cases that operative reduction (arthrotomy) is to be considered the normal procedure in irreducible dislocation of the hip, since, especially in young individuals, it gives much better functional results than resection. In more than half of the twenty-four cases a normal, or at least a good functional, result was obtained. There is a choice of several incisions: Kocher's behind, Langenbeck's over the trochanter, etc.; but Hoeflinger would give the preference to the temporary resection of the trochanter of von Mikulicz as giving best access to the parts with least traumatism. The adductor muscles may have to be cut (tenotomy), the capsule freely opened, and the acetabulum cleared of remnants of capsule, fibrous masses, or fragments of bone. Resection should be reserved as a last resort, but will in some cases give useful function. In older cases in which other attempts have failed, Koenig advises osteotomy as an operation which will improve the position of the limb.

Dislocations of the Knee Joint.—Notwithstanding its exposure to violence, the knee joint is not frequently dislocated, doubtless because of its broad articular surfaces and its remarkably strong ligamentous apparatus. Malgaigne, however, observed eighty cases and on this basis worked out an elaborate classification.

Partial dislocation of the tibia on the femur may be produced by comparatively slight force, but complete dislocations are severe injuries accompanied by wide tearing of the capsule and other ligaments. For the same reason complete dislocations of the knee are apt to be complicated with fracture, injury of the semilunar cartilages, the popliteal vessels, nerves, etc., and may be compound. The complications are much more likely to lead to serious consequences than the dislocation itself. The semilunar cartilages may be fractured or may be torn loose and displaced. The popliteal vessels may be torn across, giving rise to extensive hæmatomata and to gangrene of the leg from destruction of the blood supply. Crushing and thrombosis or even compression if continued long enough, as in delayed reduction of a dislocation, may lead to the same result. Simple pressure of the displaced lower end of the femur and upper end of the tibia, if permitted to continue for some time, may cause necrosis of the tense skin and secondary perforation, with all the dangers of infection of the knee joint. Even aseptic inflammation and swelling confined by the tense skin may so obstruct the circulation as to cause gangrene of the lower leg. The deformity presented by complete dislocation of the knee is extreme because of the large size of the lower end of the femur and the upper extremity of the tibia.

Dislocations of the tibia are described as forward, backward, lateral, and rotary (right and left).

Dislocation forward is ordinarily produced by hyperextension and might therefore be expected to be more frequent than backward dislocation because of the sharp limitation of extension of the normal knee joint, while flexion is limited only by contact of the yielding muscle masses of the ham and calf. In hyperextension the posterior and crucial ligaments are torn and the rounded ends of the femoral condyles pass into the popliteal space. Subsequent flexion forces the posterior edge of the upper extremity of the tibia upward, and the tibia lies with its posterior surface in contact with the anterior surface of the femur. In many particulars this dislocation is comparable to the corresponding dislocation of the phalanges. Dislocation forward has also been caused by a severe blow on the lower part of the femur from in front, the leg being fixed or its inertia serving as fixation.

The leg is held in extension, but may be slightly flexed. The upper end of the tibia is prominent and its articular surface may be made out by palpation. There is a concavity above in which the patella is to be felt higher than in its normal position and rotated about a transverse axis and capable of being moved about. The condyles of the femur, covered with tightly stretched soft parts, are prominent in the popliteal region. In complete dislocation there is marked shortening of the limb. The leg has a considerable degree of mobility laterally, though but little antero-posteriorly.

Dislocations of the tibia backward are more frequently partial and for the most part are caused by blows on the anterior surface of the tibia, especially when the leg is flexed, as in falls on the bent knees. The position of the leg varies according to whether the articular surface of the tibia has or has not slipped entirely off the condyles. In partial dislocation, therefore, the leg is more or less flexed, the femoral condyles are prominent in front, and the ligamentum patellæ is tightly stretched between them. In complete backward dislocations the leg is extended or even hyperextended, the condyles are prominent as before, but the head of the tibia is much more prominent posteriorly than in partial dislocations. The patella is dragged down between the condyles. There is marked shortening.

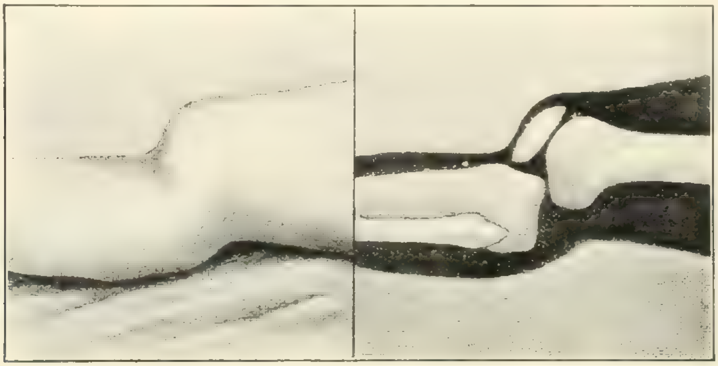

FIG. 49.—Incomplete Dislocation of the Tibia Backward. (After Lejars.)

The sharp posterior edge of the upper extremity of the tibia is apt to crush or lacerate the popliteal vessels or nerves. The ligamentum patellæ may be ruptured, but is more commonly torn off from its tibial or its patellar attachment. (Fig. 50.) The patella may be fractured.

Partial lateral dislocations are not common, but complete lateral dislocations are exceedingly rare and are severe injuries accompanied by extensive laceration of the ligamentous apparatus. When one considers the fact that in an extended normal adult knee there is practically no lateral motion, even the great breadth of the articular surfaces and the extraordinary strength of the ligaments would seem scarcely to account for the relative infrequency of lateral dislocations. One must look, for an explanation, to the protection given the joint by flexion in moments of receiving lateral injury, for these dislocations occur as a result of forced lateral flexion when the leg is locked in complete extension. If the knee is partially flexed a blow on the side of the knee will cause the whole limb to be rotated inward or outward (adduction or abduction) according as the blow is received on the outer or the inner side of the knee, thus yielding to the force of the blow. Because of the obtuse angle between tibia and femur a blow on the outer side is more likely to produce rupture of the opposite lateral ligaments than a blow of equal force on the inner side. This, together with the fact that blows are more frequently received on the outer side than on the inner, would seem to account for the greater frequency of laceration of the internal lateral ligaments.

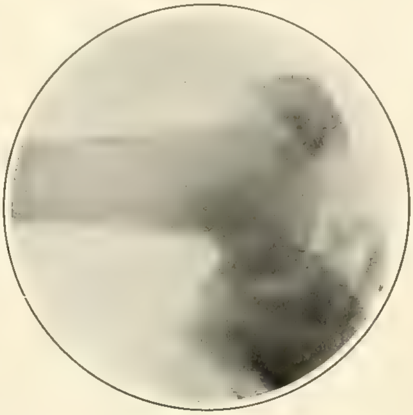

Fig. 50.—Partial Dislocation of the Upper End of the Tibia Backward, with Rupture of the Patellar Tendon. View taken from the outer side of the limb. (Roentgen Department of Lane Hospital, San Francisco.)

In partial lateral dislocations the ligaments on the side of the convexity are torn, there is more or less lateral displacement of the head of the tibia to that side, and there is also slight diastasis of the articular surfaces. (Fig. 51.) There is marked increase of lateral angular mobility in the direction of the primary deformity, *i.e.*, toward the side opposite to that of the laceration of the ligaments. In disease of the knee attended with flexion at this joint, subluxation with eversion of the foot, due to contraction of the external hamstrings, is of common occurrence.

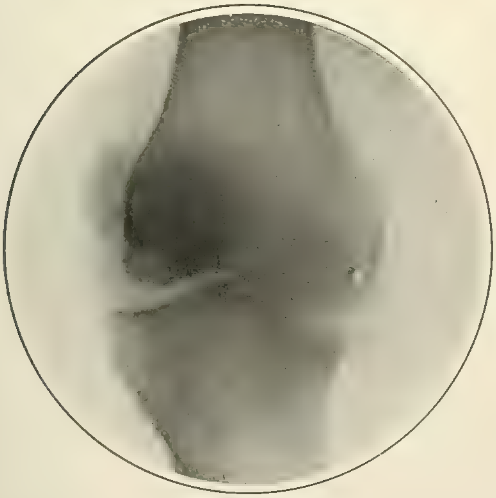

Fig. 51.—Partial Lateral Dislocation of the Tibia, Showing Angular Deformity and Lateral Displacement. (Roentgen Department of Lane Hospital, San Francisco.)

Treatment.—The reduction of recent forward dislocation of the knee is readily effected in most cases by simple manual pressure, perhaps with moderate traction. There are two principal methods for this manipulation: one by flexion followed by longitudinal traction; the other (reversing the mechanism of production of the dislocation) by hyperextension and forcing the head of the tibia downward, *i.e.*, making traction in the line of the femur, completing the manœuvre by bringing the tibia down to the straight position. Where these methods do not succeed, reduction may be accomplished by section subcutaneously, or by open incision of the edges of the capsule, with enlargement of the rent through which the end of the femur passed. It is scarcely necessary to add that the greatest antiseptic precautions are to be taken if incision be made.

Diastasis or separation of the lower epiphysis of the femur may greatly resemble dislocation of the knee. Although such injuries are more properly classed with fractures the following case observed by Luxembourg (*Deut. Zeit. f. Chir.*, July, 1907) sufficiently resembles dislocation to warrant its description here:—

The boy, while walking along a country road, was struck by a heavily-laden truck and thrown to some distance. He was picked up in an unconscious condition and carried immediately to the hospital. When he had regained consciousness an *x*-ray photograph of the injured knee (Fig. 52, *a* and *b*) was taken, and the dislocation was reduced under anaesthesia. At the end of six weeks the boy was dismissed cured. An examination made about six months later showed that the cure was of a permanent nature; no traces of the injury of any kind were discovered.

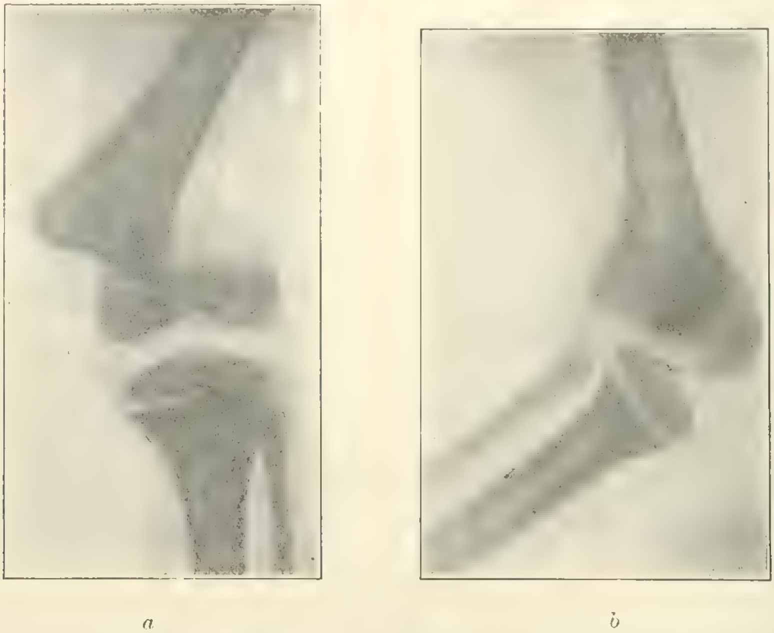

FIG. 52.—*x*-Ray Picture Showing Complete Separation of the Lower Epiphysis of the Femur and Dislocation of the Same in a Lateral (Outward) Direction. *a*, Front view; *b*, side view. (After Luxembourg, in the *Deutsche Zeitschrift für Chirurgie*, July, 1907.)

Dislocations of the Upper End of the Fibula.—A few cases are on record of isolated dislocation, or rather diastasis, of the upper end of the fibula. It has occurred as a result of discrepancies in rate of growth of the tibia and fibula—*i.e.*, where the more rapid growth of the tibia pulls the whole fibula downward, or where, in case of retarded growth of the tibia (osteomyelitis, destruction of epiphyses), the more rapid growth of the fibula forces the head of the fibula upward and outward out of its joint. In case of weakness of the ligaments of the tibio-fibular joint from any cause (*e.g.*, hydrops, in which condition this joint in fifteen per cent of cases communicates with the knee joint) traction of the biceps may pull the fibula backward. (Hirschberg, *Langenbeck's Arch.*, XXXVII.) True traumatic dislocation of the upper end of the fibula may occur alone, but is more frequent as a complication of fracture of the tibia or of the fibula.

The peroneal nerve is apt to be injured and in consequence there is more or less extensive peroneal paralysis. The most marked symptom is inability to extend the leg. There is some deformity, and palpation shows the position of the head of the fibula, as well as the degree of tension or relaxation of the biceps tendon, according as the displacement is in a forward or a backward direction.

Reduction is to be effected by direct pressure, the knee being flexed to relax the biceps. The leg should be put up in plaster of Paris in moderate flexion.

Dislocations of the Semilunar Cartilages.—Injuries of the semilunar cartilages are described under dislocations, although logically they are more properly classed with sprains. The clinical entity was designated by Hey as internal derangement of the knee as long ago as 1805, but only in recent years has the pathology of the condition been made clear, and that as a result of modern operative work.

The clinical picture of a knee which, as a result of an injury, perhaps of minor degree, becomes suddenly locked in partial flexion, being acutely painful,—the patient being unable voluntarily to extend the joint, to get the heel to the ground, or to bear the weight of the body on the leg, and the symptoms all disappearing after some form of manipulation of the leg,—is characteristic. It is, however, similar to that of a loose body in the joint. The pain is perhaps less severe, recurrence less frequent, and something may be determined by palpation as to the size of the projecting loose body. The fact is, however, differentiation between these two conditions is not always possible. They may coexist. A Roentgen picture is of diagnostic value in that a loose body in the joint generally contains sufficient bone to make a shadow, while with simple fracture or dislocation of the semilunar cartilages the joint appears normal. (Hoffa.) The cartilage may be displaced as a whole and lie in the cavity between the femoral condyles or project forward, forming a palpable and even visible prominence, or it may be fractured, the fragments separating one from the other, or a chip may be broken off, forming a loose body in the joint. There is a marked tendency to recurrence, and some individuals are unable to flex the knees fully without this displacement occurring. Generally, manipulation (pressure on the projecting meniscus, with passive extension) immediately relieves the symptoms, but occasionally fails and the joint remains stiff.

While the semilunar cartilages may be injured by direct violence, as by blows from more or less pointed objects, they are much more often injured as a result of some twist of the leg in partial flexion, as an exaggeration of the normal axial rotation of the tibia. Physiological rotation of the tibia varies in individuals, is much greater in childhood, and also varies with the relative position of tibia and femur, being zero when these bones are locked in complete extension and reaching a maximum in flexion of from forty to sixty degrees. (Testut.) Maximum active rotation varies from fifteen degrees to twenty-five degrees, and passive from thirty-five degrees to forty degrees.

Injuries and displacements of the internal meniscus are much more common than of the external (five or seven to one), which is probably to be explained by the less firm attachment of the internal meniscus, its lesser concavity, and the greater frequency of accidents producing excessive external rotation and abduction; both of these motions appear to be of etiological importance, the common turning outward of the foot favoring external rotation, and the obtuse angles at the knee favoring abduction. Displacement of the external meniscus is due to exaggerated internal rotation and adduction.

Unless the displaced cartilage is restored to its proper position the prognosis is not a happy one. The knee continues to be painful and all but useless, and that too despite all the measures—massage, exercise, elastic bandages, splints, etc.—employed for the relief of the condition. There is a marked tendency to recurrence of the displacement when reduction has been accomplished. Even with operative replacement of the displaced meniscus the knee is apt to be more or less troublesome, partly because of imperfect adjustment and altered mobility of the meniscus, partly because of disturbances in the relations of the ligamentous apparatus, and because of atrophy of the thigh muscles. So great has been the muscle atrophy in some cases as to suggest that it is due to a neuritis resulting from the injury rather than from simple non-use. (Martina: *Deutsche Zeit. f. Chir.*, LXXXVIII., p. 370.)

Treatment.—In a considerable proportion of cases the displaced cartilage can be replaced by a manipulative process reversing that by which it was thrown out; *i.e*, the internal meniscus when tilted into the space between the condyles can be pushed back into its normal position by making extension of the leg, followed by sudden flexion and rotating inward (the outer meniscus by rotating outward), while pressure is made on the prominent portion of the fragment with the fingers.

After reduction of the cartilage the knee should be fixed for about six weeks in plaster of Paris.

Open operation is indicated in chronic cases which manifest a tendency to recurrence, and in acute cases where efforts at reduction have failed. The joint may be opened by a vertical incision along the adjacent border of the patella or by a transverse incision, and, according to the judgment of the operator, the fibro-cartilage should be sutured at the point of fracture, and anchored to the capsule with absorbable suture (catgut or fine kangaroo tendon) or else extirpated. When the cartilages are displaced backward between the articular surfaces, flexion of the leg to complete relaxation, with rotation and abduction from the injured side, offers a chance of restoration. In these cases, however, the coronary attachments are torn, and it is more than likely that only operative relief will suffice. It may be difficult to reach the point of fracture of the cartilage, but flexion and extension movements, with rotation, will expose different portions of the cartilages. The capsule should be sutured and the joint closed. The removal of part or even all of a meniscus seems not to interfere seriously with the function of the joint.

Dislocations of the Patella.—The patella, the largest of the sesamoid bones, is developed in the tendon of the quadriceps extensor. Being attached to the upper portion of the tibia by a ligament of very great strength, it moves over the trochlear surface of the femur in extension and flexion of the leg. The range of motion is considerable, 6 or 7 cm. ($2\frac{2}{5}$ or $2\frac{4}{5}$ in.). Laterally, the patella moves from 1 to 3 cm. ($\frac{2}{5}$ in. to $1\frac{1}{5}$ in.) when the quadriceps is relaxed. It is so freely movable in all directions and is so easily tilted by pressing on any of its various edges that a sharp blow applied on almost any edge will cause it suddenly to emerge on the opposite side and tilt to a greater or less degree. Thus dislocations have been produced in all directions, although only in rare cases in an inward direction.

Theoretically, the patella may be dislocated laterally to either side, but complete dislocation inward is so rare that for practical purposes it may be said not to occur. Of two cases quoted by Malgaigne one was accompanied by such relaxation of the ligaments that the patella could be moved widely in any direction (pathological luxation), and the other was doubtful. The lateral dislocations are described as partial or complete.

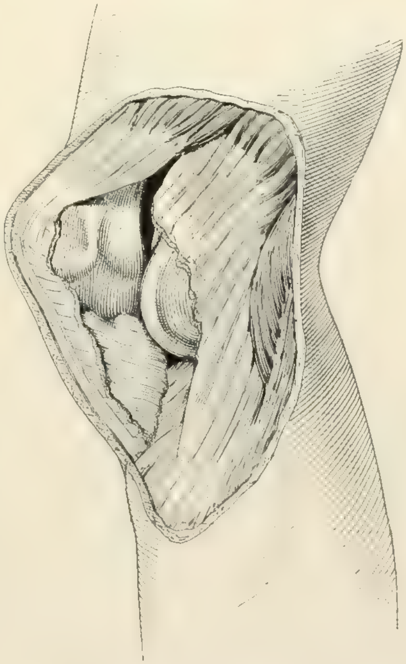

Fig. 53.—Vertical Dislocation of the Patella. (After Anger.)

The patella may be rotated upon edge, *i.e.*, with articular surface "looking" toward the inner or toward the outer side of the knee, or may be, though very rarely, turned completely over, and may even be rotated about a transverse axis.

Lateral dislocation outward is favored by the lateral angle between thigh and leg, which varies with individuals and is greater in the female than in the male because of the wider pelvis. Naturally, this dislocation is more common in the presence of genu valgum.

Resisting the tendency to dislocation are the higher outer rim or crest of the trochlear surface and the lateral ligamentous apparatus (capsule, quadriceps aponeurosis, and lateral patellar bands—retinacula patellæ), together with the tension of the vastus internus, which is greater in volume and strength than the externus.

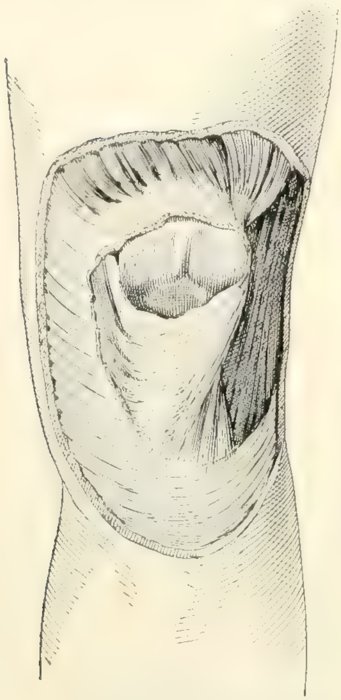

Fig. 54.—Dislocation (Total Reversal) of the Patella. (After Anger.)

Dislocation of the patella outward is said to be complete when the articular surface of the patella has passed completely to the outer side of the trochlea and the inner edge of the patella is caught against its outer border. This dislocation is described as of two varieties—one taking place above the prominent outer edge of the trochlea, the other below. The former occurs by muscular action in sharply forced extension, or by direct violence from below upward and outward when the leg is in extension. The latter may occur from direct violence from above downward and outward, but occurs chiefly from blows on the inner side when the leg is partially flexed. Contraction of the quadriceps may, according to circumstances, increase or diminish the dislocating effect of such blows.

Rotary dislocation, constituting one-sixth of all dislocations of the patella, occurs most frequently with the knee flexed and as the result of direct violence. The greater frequency of rotary dislocation with articular surface outward (two-thirds of all cases) is to be accounted for by the obliquity of the plane of the trochlea and the prominence of its outer edge or crest. When the patella is set on edge it is maintained in its position by tension of the quadriceps and untorn portions of the ligamentous apparatus. The knee is partially flexed and the edge of the patella lies in the upper portion of the intercondyloid notch.

In all dislocations of the patella the capsule and the ligaments are more or less torn and may be torn widely, and there may be great effusion of blood within and without the joint, obscuring the condition and interfering with replacement.

Reduction may be accomplished in most cases and without an anæsthetic, but in others it is not possible except by open operation—incision. The quadriceps should be relaxed by passive flexion of the thigh and extension of the leg. The patella may then be lifted with the fingers up over the crest of the trochlea into place, or in rotary dislocations the patella may be turned by gripping it with the fingers.

After reduction is secured the knee should be alternately flexed and extended a few times to assist in securing better apposition of torn ligaments, and the limb should be placed in a plaster-of-Paris or other fixation splint. If the effusion is great it should be removed by aspiration and the joint bandaged.

In case of failure to secure reduction the knee should be opened under the strictest asepsis, the joint cleared of clots, the torn ligaments trimmed, and, after replacement of the patella, the wound should be sutured. The introduction of hooks, elevators, etc., through small incisions is even more objectionable from an aseptic standpoint than open operation and should therefore be discarded.

Dislocation by rotation about a horizontal axis is claimed by Cheeseman to be not so rare as commonly supposed (*Ann. Surgery*, 1905, XLI., p. 107). He collected five cases from the literature and reported a sixth. In his case the quadriceps tendon was torn and the upper edge of the patella wedged so tightly into the intercondyloid notch as to resist all attempts at dislodgment even under anæsthesia. Open incision permitted lifting of the patella into its correct position and suturing of the quadriceps tendon. Of the six cases only one was reduced without operation. In two the patella lay between the tibia and the external condyle. In four the quadriceps tendon was ruptured, the ligamentum patellæ in one, the crucial ligaments in two, and the lateral ligaments in one.

After luxation of the patella there is a marked tendency to habitual dislocation, to prevent which the retentive dressing should be continued until healing of torn ligaments is firm, and subsequently for a considerable time a supporting bandage should be worn.

If habitual dislocation is once established as the sequence of a traumatic dislocation, of chronic hydrops, of genu valgum, or of impaired action of the vasti muscles, a supporting bandage, consisting of a leather knee cap with a hole in it for the patella and padded so as to make pressure on the outer side, will give a considerable degree of relief. Various operative procedures have been tried with varying success. Open operation with suturing of tissues on the inner side under proper asepsis is to be preferred to subcutaneous suture. The operation of Le Dentu has given good results. It is described as follows by Hoffa (*Langenbeck's Arch.*, LIX., 1899, p. 547): An incision 11 cm. ($4\frac{2}{5}$ in.) long is made about midway between the inner border of the patella and the capsule of the knee joint. The soft tissues are pushed away by a blunt instrument on both sides of the capsule, so that on the outside the border of the patella with its tendinous envelope, and on the inner side an area of the capsule at least an inch wide, are laid bare. The patella is next forcibly pressed toward the middle line of the limb and four strong silk sutures are carried, on the one side, through the tendinous and periosteal covering of the patella and on the other through the aponeurosis of the internal condyle of the femur, in order to draw the patella inward. These sutures are not yet tied, but are held firmly by an assistant. The capsule lying in the area of the incision is now seen markedly relaxed and stretched. It is folded into a sausage-shaped roll, gathered together, and sewed with six silk sutures into a compact cord. This cord holds the patella well toward the middle line, but it is secured more firmly in its proper position by knotting the sutures first introduced. After removal of the Esmarch bandage (applied before the actual operation began), the small amount of bleeding is arrested, the wound in the skin is closed by silk sutures, and sterile compresses and bandage are applied. The leg being well extended, a plaster-of-Paris bandage is applied from above to the metatarsal capitulum, and while it is hardening pressure is maintained against the external border of the patella.

Diastases of the Distal End of the Fibula.—Except as a complication of Pott's fracture and of dislocation of the astragalus, diastasis of the lower end of the fibula is exceedingly rare. Stimson found but two cases in the literature. When one considers the exposure of the prominent external malleolus to violence, the rarity of this dislocation is explained by the frequency of fracture of the fibula or of the malleoli. In these two cases the lower end of the fibula was freely movable backward and forward, and the outer surface of the astragalus could be outlined by the finger. In one (Nélaton's, a chronic case) the function was so good that interference seemed unjustifiable. In the other (Tillaux's) the bone was put into place and kept there by suitable bandages, and the patient made a satisfactory recovery. Stimson saw one case with backward dislocation; the foot was in abduction. Adduction brought the fibula into place with an audible snap, then the dislocation was reproduced by abduction, and again reduced by adduction of the foot. Diastasis of the lower tibio-fibular joint has recently been the subject of an elaborate study by Quenu (*Rev. de Chir.*, XXXV., p. 898 *et seq.*, 1907.

Dislocations of the Foot.—The astragalus is so fitted between the malleoli that the ankle joint permits of practically no motion except those of flexion and extension. Complicated motions of adduction and abduction, pronation and supination are combinations of rotation in the mediotarsal (between scaphoid and astragalus, cuboid and calcaneus) and astragalo-calcanean joints. These joints move simultaneously in varying degree, the freest motion taking place between the head of the astragalus and the scaphoid.

Dislocations of the tarsus and its various elements are so closely allied and so similar that they are commonly described together. In general, four groups are distinguished: dislocations of the ankle joint proper (luxatio pedis), dislocations of the astragalo-calcanean joint (luxatio pedis sub talo), dislocations in the mediotarsal (Chopart joint), and dislocations of individual bones of the tarsus.

These dislocations are so frequently complicated by fracture, and the differential diagnosis between them and fractures in this neighborhood is so difficult, being so frequently obscured by excessive swelling and effusion of blood, that an *x*-ray picture should be made in all cases.

These injuries are always severe and are accompanied by extensive damage to the soft parts. From this may result perforation of the skin, making the lesion compound, local necroses of greater or less extent, and even gangrene of a large part of the foot.

If we exclude the dislocations of the foot of greater or less degree, which are very common as complications of Pott's fracture and fracture of the malleoli, dislocations of the foot are of only moderate frequency. Wendel (*Beit. z. klin. Chir.*, XXI.) gathered one hundred and eight cases and described the following forms: 1, dislocations forward and backward; 2, lateral dislocations by pronation and supination, as well as by eversion and inversion; 3, dislocations upward.

Dislocations forward commonly result from excessive plantar flexion (tarsal extension), whether from falls forward, striking on the dorsum of the foot, or from falls backward, the foot being caught as between two timbers, perhaps with added thrust forward on the foot. In some cases it is probable that, in exaggerated dorsal flexion, the lateral ligaments being torn, a blow or thrust on the back of the heel drives the foot forward. (Fig. 55.)

This dislocation may be complete or incomplete. Atypical forms are observed in which there is complicating fracture, *e.g.*, of the astragalus, one portion being dislocated, the other remaining in the joint.

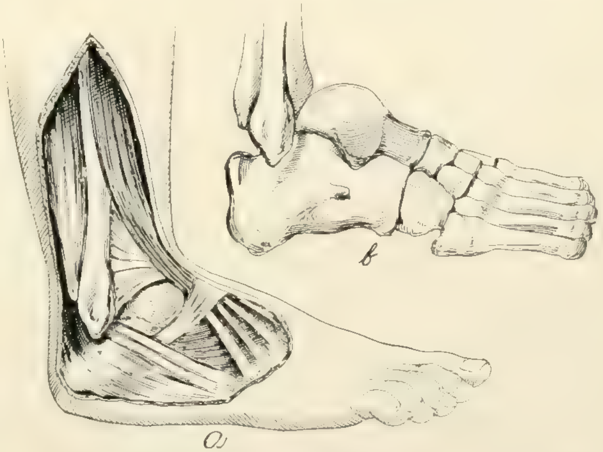

Fig. 55.—Dislocation of the Foot Forward. (After Helferich.) Note the absence of the normal projection of the heel backward. *a*, Relations of the parts as seen after a superficial dissection; *b*, relations of the bones alone.

The foot is lengthened in front and shortened behind. The malleoli approach nearer the sole, the foot is apt to be in moderate plantar flexion (tarsal extension), and the hollow of the instep may be increased. Unless the swelling be too great the upper surface of the astragalus can be palpated.

Dislocations backward are much more common than dislocations forward. They usually occur in extreme plantar flexion, by which the anterior and lateral ligaments are torn, the astragalus rotating about the posterior end of the tibia. The displacement backward occurs as a result of thrust from in front.

The foot is displaced backward and is held in moderate plantar flexion, the heel being apparently lengthened in proportion as the front of the foot is shortened. (Fig. 56.) The lower edge of the tibia projects in front and can be felt immediately beneath the skin. It not uncommonly perforates the skin, making the dislocation compound.

The dislocation may be complete or incomplete, the posterior edge of the articular surface of the tibia catching on almost any point of the dorsum of the astragalus.

Reduction of these dislocations is generally effected without difficulty, the manipulations being chosen to fit the particular case.

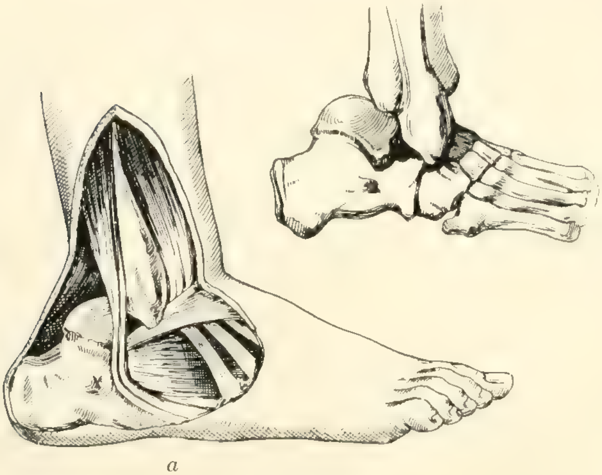

FIG. 56. — Dislocation of the Foot Backward. (After Helferich.) Note the abnormal projection of the heel backward. *a*, Relations of the parts as seen after a superficial dissection; *b*, relations of the bones alone.

Lateral dislocations may be inward or outward (dislocations by pronation and supination). Of these the outward is about twice as frequent as the inward.

In the use of these terms by different authors there are great discrepancies, some referring to the position of the foot as a whole, in the sense of inversion and eversion, and others adhering more strictly to the position of the astragalus with reference to the tibia. By dislocation inward one would mean not so much inversion of the foot, which may be present when the astragalus lies beneath the outer malleolus, as the dislocation in which the astragalus lies beneath or internal to the inner malleolus, independently of whether the foot be adducted or abducted.

Dislocation inward (*Pronationsluxation*, Wendel) results from a force applied on the inner side of the heel, forcing it outward and upward—the astragalus either breaking the outer malleolus or the fibula above, as in Pott's fracture, or turning about the malleolus as a fulcrum, tearing the internal lateral ligaments. The astragalus is then forced inward and lies more or less beneath the inner malleolus—the foot remaining in abduction. The astragalus may, however, be driven completely past the inner malleolus and lie with its outer edge against the inner surface of the malleolus. In this case the abduction of the foot is much less marked.

Dislocation outward is caused by the opposite mechanism, and the position of the foot is the opposite.

Dislocation of the ankle joint may be caused by rotation alone about a vertical axis, *i.e.*, by eversion or inversion. In the former the fibula is pressed backward by the anterior portion of the astragalus, whose posterior border slips forward till it rests on the inner malleolus. The astragalus remains between the malleoli, but, with the foot, is rotated outward to approximately a right angle. In a case of Stimson's the fibula was broken in its upper third.

Rotary dislocation outward (*Supinationsluxation*) is much rarer than the preceding. It is brought about by the opposite mechanism and is characterized by the opposite deformity.

Between these typical cases there are others in which the forces active partake of rotations about vertical and antero-posterior and transverse axes together in varying degrees, giving atypical deformities.

Treatment.—Replacement has generally been effected without great difficulty and by a mechanism reversing that by which the dislocation in the given case was produced—*i.e.*, in internal dislocation with abduction, the abduction should be exaggerated, the foot drawn outward, and then adducted; in external dislocation the opposite is required. In rotary dislocations the parts can be relaxed somewhat by extension, when with slight force the foot may be rotated in the desired direction. Manual pressure may aid in restoration. Relaxation of the tendo Achillis, as brought about by flexing the knee, is of great assistance. In a few of the cases reported tenotomy had to be resorted to before reduction was possible.

In compound or infected dislocations of the ankle, amputation or excision was formerly required, but more recent work has shown that if the wound be given the modern treatment of compound fractures—thorough cleansing, with or without free incision, and restoration of the natural relations—excellent results are often obtained. In general, the contused edges of the wound of perforation should be cut away. In most cases drainage is required and should be made from both inner and outer sides, and the joint should be fixed in a suitable plaster-of-Paris dressing. Excision of the astragalus is not often required.

In case of comminuted fracture as a complication, as shown by the x-ray, it may in the judgment of the surgeon be preferable to open the joint primarily and remove the loose fragments—of course, closing the joint under the strictest asepsis.

In old unreduced dislocations there are great deformity and great functional disability, and after partially successful reductions there are apt to be pain and limping. In such cases attempts at reduction may legitimately be made under an anæsthetic, and they have succeeded, in reported cases, after some months. If reduction is not effected either in fresh cases or in old, operative reduction may be tried or resection of the astragalus performed. It should be remembered, however, that ankylosing adhesions in the ankle, even when they have existed for several months, will gradually, as a result of the exercise of walking, give way and some degree of motion be restored. Furthermore, the other joints of the tarsus gradually increase their range of motion to compensate for loss of ankle motion, especially in young people. A small range of motion between astragalus and tibia markedly lessens the limp of ankylosis and gives a better foot than where the astragalus is removed.

By dislocation upward is somewhat inaccurately designated the rare deformity which results when from a fall the tibio-fibular ligaments are torn and the tibia is thrown forward and the fibula backward, the astragalus being forced upward between the two. Sargent (*Lancet*, 1903, II.) reported a typical case caused by exaggerated dorsal flexion, the wider anterior portion of the astragalus forcing the malleoli apart. The foot was firmly fixed in its new position. Reduction was easy by simple traction under anæsthesia. Massage and passive motion were begun on the third day, and after three weeks the patient could walk with but little limp. Recovery was complete.

Subastragaloid Dislocation.—The most important dislocation within the the tarsus itself is the so-called dislocation beneath the astragalus or subastragaloid dislocation (luxatio sub talo). It would seem that the same sort of forces which in one case will produce a Pott's fracture, in a second a dislocation of the foot, will, in a third case, produce dislocation beneath the astragalus (subastragaloid dislocation). Minute differences as regards the point of application and the direction of the dislocating force, and the changes in them during their time of action, must account for such clinical differences.

Broca first gathered these cases together in 1852, and since then a large number of cases have been reported. Henke described four typical forms of subastragaloid dislocation—the result of forced adduction, abduction, plantar flexion, and dorsal flexion respectively. Trendel collected eighty cases up to 1905. (*Beit. z. klin. Chir.*, XLV.) Of these, forty-six were lateral, five forward, two backward, and fourteen oblique. Baumgaertner and Huguier (*Rev. de Chir.*, XXVI., p. 230) collected eighty-cases, of which twenty-four were complicated by fracture.

These dislocations are all the result of severe force and are not infrequently compound. Baumgaertner and Huguier (*Revue de Chir.*, 1906) figure several typical cases, giving radiographs which show the relations of the various bones. Exaggerated abduction causes the calcaneus to roll outward on the outer edge of the astragalus, tearing the interosseous ligaments to a greater or less extent. The limit of rotation in the astragalo-scaphoid joint being reached, its capsule is torn and the foot, all but the astragalus, is forced outward and backward. Clinically the foot has the appearance of a severe case of flat-foot: it is everted and the astragalus makes a marked bulging on the inner side in front.

Similarly, exaggerated adduction causes the calcaneus to tilt on the tip of the sustentaculum tali until the interosseous ligaments give way, when displacement inward takes place. The foot resembles a club-foot, is adducted and flexed, and the astragalus appears as a bulging on the outer side. Not infrequently the neck of the astragalus is broken. (Trendel, *loc. cit.*, and Luxembourg, *Deutsche Zeit. f. Chir.*, LXXXVI., p. 127.) (Fig. 61.)

In either of these dislocations the scaphoid may be left on the astragalus, and the separation in front be between the scaphoid and the cuneiform bones, though this is the exception. This dislocation has been described as dislocation of the foot below the scaphoid.

Dislocations forward and backward below the astragalus occur as the result of dorsal and plantar flexion respectively. In deformity they resemble the corresponding dislocation above the astragalus, but differ strikingly in that they permit a considerable degree of flexion and extension. Careful palpation will show the positions of the bony prominences.

Treatment.—Reduction of the lateral dislocations is to be made with the knee flexed, to relax the tendo Achillis, and by forcible adduction in outward dislocations and abduction in inward, with traction on the foot, while the parts are being pressed into position with the fingers. Because of the irregularities of the under surface of the astragalus and the upper surface of the calcaneus, perfect adjustment is difficult to secure, and if not secured the functional result will not be satisfactory. Ends of torn ligaments, fringes of capsules, etc., may be interposed. The x-ray is the best means of detecting minor degrees of displacement. In dislocations inward and backward Malgaigne advised forcible extension of the foot, but Quenu has shown (*Bull. de la Soc. de Chir.*, 1894, p. 130) that portions of the annular ligament, slipping beneath the head of the astragalus, may make reduction impossible except by forced flexion. Baumgaertner and Huguier, on the basis of experiments on the cadaver, have shown that there are two classes of such dislocations—one which can be reduced by extension, the others by flexion.

Dislocation in the medio-tarsal (Chopart's) joint is exceedingly rare. In fact its existence has been denied altogether. Broca thought it impossible on anatomical grounds. There have been reported, however, a few cases which definitely establish this dislocation as a clinical entity. (Fuhr, *Muench. med. Woch.*, 1892.) Morian (*Deutsche Zeit. f. Chir.*, LXXXVI., p. 117) succeeded in collecting ten cases from the literature, and reported one case of isolated dislocation of the astragalo-scaphoid joint which he himself had observed. (Fig. 62.) The anterior part of the foot may be dislocated outward or inward. The deformity is much like that of the dislocation below the astragalus, but is differentiated therefrom by the palpability of the rounded end of the astragalus and the changed relations of the os calcis and cuboid.

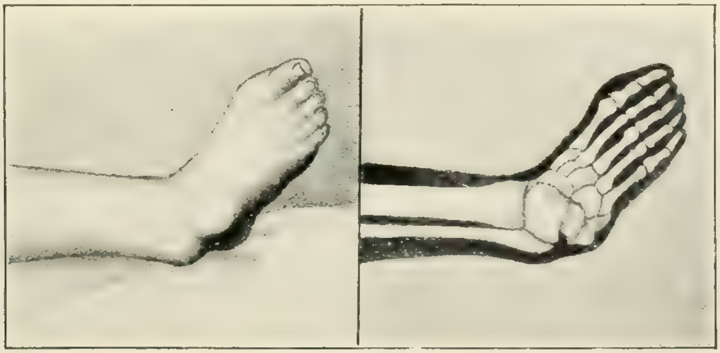

FIG. 57.—Dislocation of the Astragalus Forward and Outward. (After Lejars.)

Dislocations of Individual Tarsal Bones.—Isolated dislocations of many of the tarsal bones have been described, but, of these, dislocation of the astragalus is at once the most frequent and the most important.

The bone may be forced out from between the os calcis and the tibia, more frequently forward, but occasionally backward. The forward dislocation is the result of excessive plantar flexion, probably with added thrust. Henke considered that this dislocation was probably the result of a combination of forces, one of which would cause dislocation of the foot forward, while the other would cause a dislocation of the astragalus laterally.

In the forward dislocation the astragalus is sometimes found pushed over to the inner side of the median line of the foot, but more frequently to the outer. The head of the astragalus may be caught behind the tendon of the tibialis anticus, and this, in some cases, has interfered with reduction.

The dislocation of the astragalus backward is the result of excessive dorsal flexion with added thrust in which the anterior edge of the articular surface of the tibia impinges sharply on the neck of the astragalus. More often than not it cuts it apart as would a cleaver, the body of the astragalus being forced out of the joint posteriorly and to the inner side of the tendo Achillis, while the head of the bone remains in place. It is a question whether this injury should not be classed with fractures rather than with dislocations. In some cases the body of the astragalus is more or less comminuted, and the tibia then rests, not on the upper surface of the os calcis, but on the crushed fragment, as occurred in one of the two cases observed by the writer. (Fig. 59.)

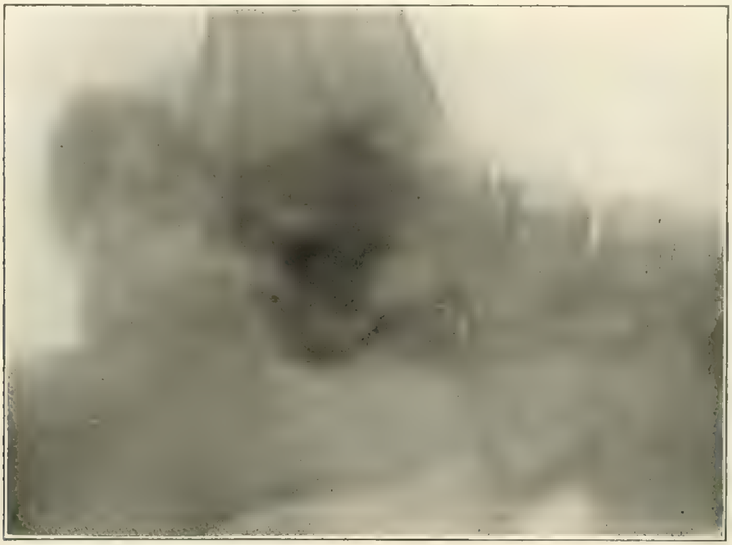

FIG. 58.—Dislocation of the Body of the Astragalus Backward, with Fracture of the Neck. (Roentgen Department of Lane Hospital, San Francisco.)

More rarely the astragulas has been rotated in place about a transverse axis or about an antero-posterior axis, as is shown in a case reported by Schlagintweit (*Deutsche Zeit. f. Chir.*, 1907). (Fig. 60.) The upper surface of the astragalus lies on the os calcis and the cuboid.

Isolated dislocation of the astragalus is the result of severe violence and may be compound.

In the *treatment*, success has followed efforts at reduction in perhaps half of the cases. The tendo Achillis being relaxed by flexion of the knee, and strong traction being made on the foot, the astragalus can often be replaced by finger pressure. In compound dislocations the bone should be replaced unless too completely stripped of its attachments to permit it to live. Chips and loose fragments of bone or cartilage should be removed. In case of failure to reduce the dislocation by manipulation under an anaesthetic, reduction may be made through an incision, and, in the absence of infection, this will give a better foot than is obtainable by removal of the astragalus. In the case of Schlagintweit (Fig. 60) reduction was effected through an incision on the outer side between the peroneal and the extensor tendons and gave an excellent result, with good ankle motion.

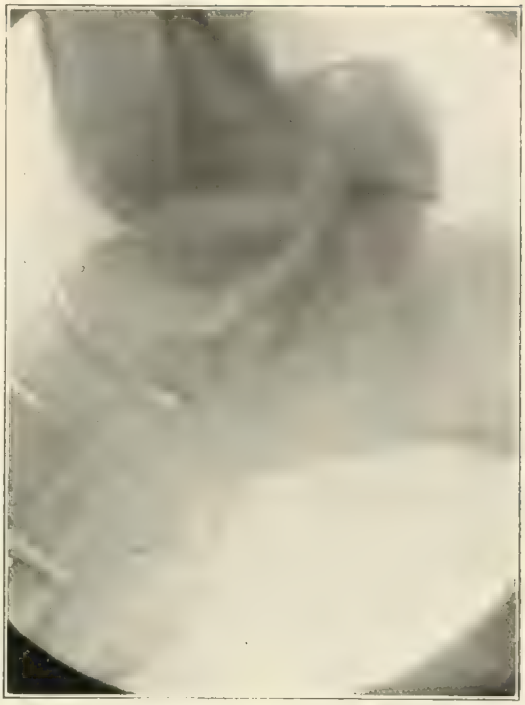

Fig. 59.—Dislocation of the Body of the Astragalus Backward, with Fracture of the Neck. (Roentgen Department of Lane Hospital, San Francisco.)

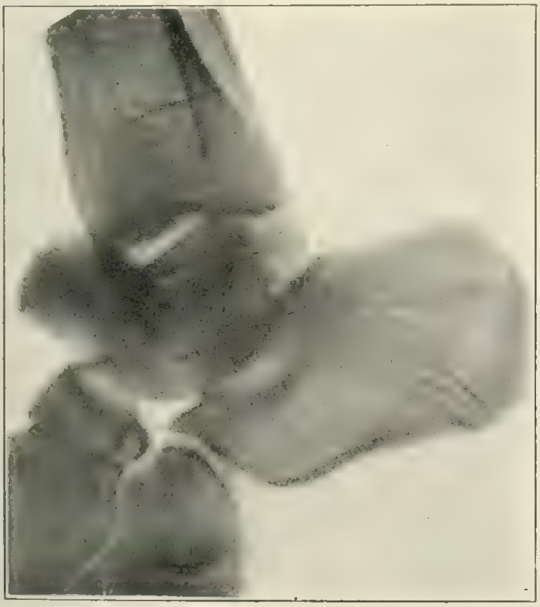

Fig. 60.—Complete Inversion of Astragalus about an Antero-posterior Axis. (After Schlagintweit.)

The case shown in Fig. 59, and a similar case of posterior dislocation of the astragalus with cleavage fracture of the neck, were operated upon by the writer. In one the displaced fragment of bone was removed, and in the other it was replaced and sutured with fine silver wire to the head. The functional result in both cases was excellent; in the second the foot appeared normal in form.

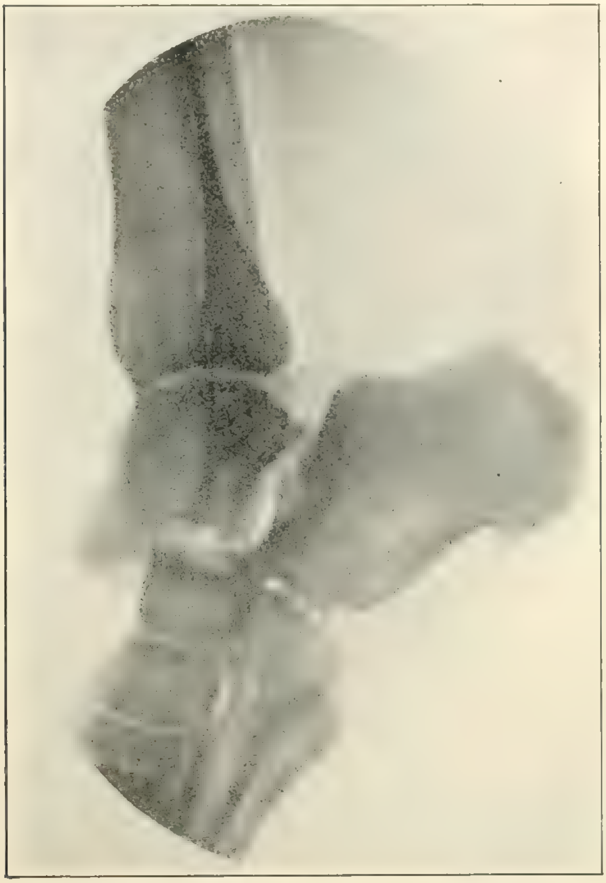

FIG. 61.—Subastragaloid Dislocation Backward and Outward, with Fracture of the Neck of the Astragalus. (After Luxembourg.)

As regards the relative frequency with which the different bones of the tarsus undergo dislocation, the scaphoid (navicular), of which the displacement may be complete or incomplete, stands next in order to the astragalus. Capillery and Ferron report a recent case in the *Revue de Chirurgie* and quote one by Walker (*Med. Examiner*, 1851). The dislocation may be inward or upward. In Walker's case, which was recent, reduction was accomplished by digital pressure after strong plantar flexion had been made. The bone was held in place by means of bandages, and the final result was a foot without deformity and with perfect function. In the case of Capillery and Ferron reduction was not secured, and the patient, refusing excision, was dismissed. A year and a half later he was again examined: the notch beneath the dislocated navicular was a little wider; and, although there was some limitation of motion at the ankle, he walked without a limp. Eichel (*Deutsche Zeit. f. Chir.*, 1907) collected nine cases of dislocation of the navicular in which the diagnosis was established without question.

The three cuneiform bones have been dislocated, as have the calcaneus and also the cuboid. According to Cahier* all three cuneiform bones or only the two external may be dislocated simultaneously; or else either the internal or the middle may alone be displaced. In a case of the first variety which came under the observation of Monteggia and Malgaigne, the three bones were found lying on the dorsum of the foot. Reduction was effected by applying extension to the toes, while the leg and heel were held firmly, and making direct pressure upon the mass of displaced bones. Rey experienced no difficulty in reducing a dislocation of the middle and external cuneiform bones, but Walker, in a somewhat similar case, found it necessary, owing to the fact that both of the bones had undergone a movement of rotation about their transverse axes, to remove them entirely. Paulet and Chauvel have collected the records of eleven cases of dislocation of the internal cuneiform bone: in four of them the displacement was upward, in four others it was inward, and in three it was downward and inward. Delorme has collected the records of three cases (Lagarde, Laugier, Folker) in which the middle cuneiform bone was dislocated upward. Complete reduction was effected in only one of these cases by simple direct pressure upon the displaced part in combination with flexion of the foot and extension of the toes. Cahier adds that, whenever it is not found possible to reduce the deformity by the simple manipulations just mentioned, no hesitation should be felt about extirpating the projecting mass of bone by operative interference.

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*"Lésions traumatiques des Articulations," in vol. iii. of Le Dentu and Delbet's "Traité de Chirurgie clinique et opératoire," Paris, 1896.

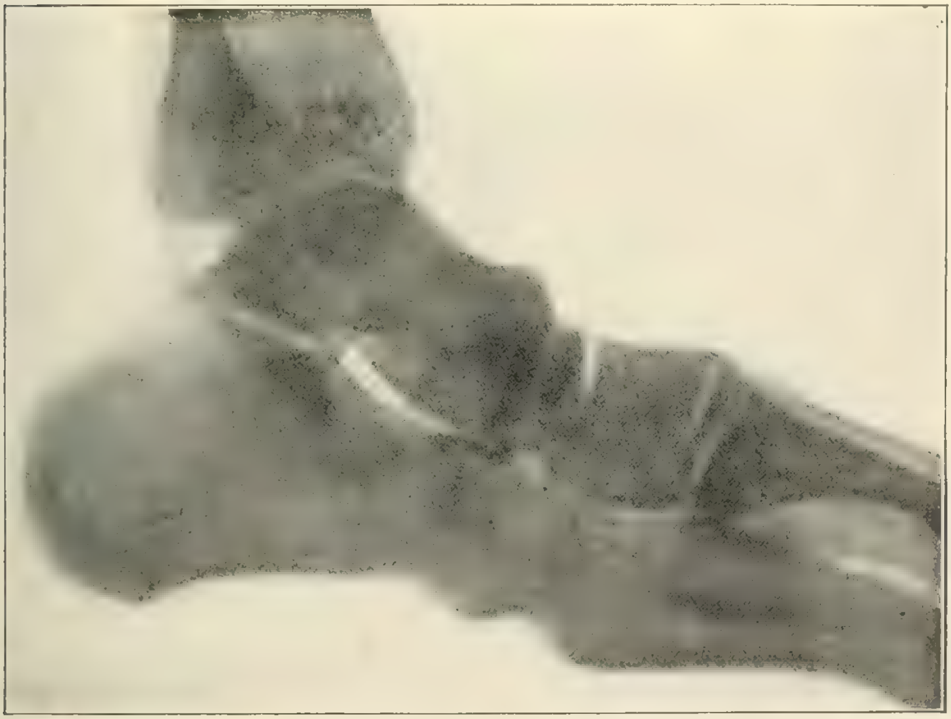

Fig. 62.—Dislocation Inward in the Astragalo-Scaphoid Joint. (After Morian.)

Dislocations of the Metatarsus and of the Toes.—The metatarsal bones have rarely been observed in dislocation. A few cases have been reported of dislocation of the metatarsus as a whole on the dorsum of the tarsus or to the inner side, as well as cases of isolated dislocation of one or several of the metatarsal bones. The diagnosis is to be based on the presence of palpable displacement, though it is not possible always to exclude fracture. The *x*-ray is of determining value.

Reduction has been effected by traction on the displaced part and by direct pressure, as circumstances require. The foot should be supported in plaster-of-Paris dressing.

The dislocations of the toes follow much the same history as do dislocations of the fingers, but the deficient state of development of the phalanges of the toes and the resulting loose joints make dislocations common or even habitual, but make reduction correspondingly easy. Dislocations of the great toe are the most important and are comparable to corresponding dislocations of the thumb. (See page 68.) The dorsal dislocation is to be reduced by exaggerating the dorsal flexion and making traction parallel to the shaft of the metatarsal, and afterward circumduction or flexion. Klaussner (*Deutsche Zeit. f. Chir.*, 1907) has collected a number of cases of dislocations of the toes, adding to the statistics of Baermann, Garnier, and Hoffa.

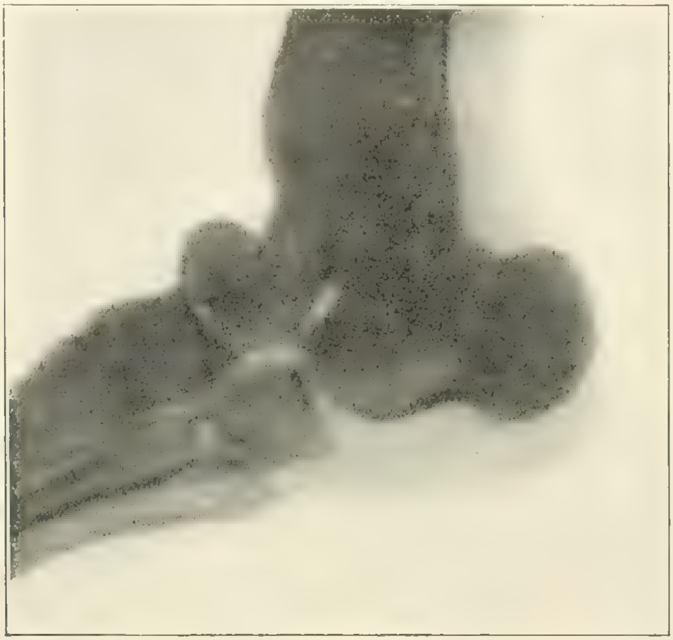

Fig. 63.—Dislocation of the Navicular Upward and Inward. (After Eichel.)

PART XIV.

OPERATIVE SURGERY.

INFLUENCES AND CONDITIONS WHICH SHOULD BE TAKEN INTO ACCOUNT BEFORE ONE DECIDES TO OPERATE.

By CHARLES B. G. DE NANCRÈDE, M.D., Ann Arbor, Michigan.

By pursuing certain lines of investigation and by skilfully balancing the probabilities for or against a given course of procedure, the surgeon can arrive at practical certainty as to whether a patient will be able to survive a given operation; can decide whether an organ or a part is more likely, after a particular intervention, to recover than to succumb; whether systems or organs upon whose efficient functioning life depends can or cannot be called upon to perform extra work with safety to the system, organ, or individual; whether unfavorable conditions can be amended, or, if they cannot, whether it be not advisable for him, despite the unusual risk and also in part because he is forewarned, to proceed; and whether operative success may not be better attained, or is perhaps only possible, by doing the work in several stages, because the patient and the tissues can often survive repeated, moderate traumatisms, whereas one or the other will perish if too much is attempted at one sitting. In the present article the effort will be made to supply such information as will enable the surgeon to decide intelligently the questions already propounded, and others of associated importance. This comprises all that should be attempted when one endeavors to formulate the general principles governing decisions as to what constitutes a contra-indication to operations in general or an operation in particular. The decision when to operate and when not to operate must depend upon the acquisition of knowledge as to the normal or abnormal condition of the various organs and systems; and also upon a correct estimate of the untoward effects upon local or general vital resistance which, as has been shown by clinical experience, are produced by the ascertained variations from the normal. Sometimes other factors demand full consideration—such, for example, as relate to the patient, the capacity of the surgeon, the probable outcome of operations of complaisance, etc.

Beyond some few illustrations which will be given, nothing more can be done; otherwise every phase of every surgical condition, including the varying conditions of patients and all conceivable complications, would have to be reviewed. To do this would require the compilation of a work including the whole of operative medicine. No hard and fast rules are possible whereby the surgeon can unerringly decide for or against operation in a given case.

Contra-indications to special operations will be dealt with under their proper captions, and, for these, more positive rules are permissible. It is of the utmost importance to determine the presence of certain systemic, anatomical, or personal conditions presently to be mentioned, conditions which may militate against the successful termination of any operation, and the known presence of which may enable the surgeon so to modify his technique that good results may be secured despite the unfavorable conditions.

The vascular, nervous, pulmonary, hæmopoietic, excretory, and gastro-intestinal conditions which may unfavorably influence operative interventions will all in turn be studied, and the real importance of the mooted question of age will be carefully considered.

Anæsthesia.—No operation requiring the employment of a general anæsthetic should be done if the patient has recently eaten a full meal of solid food or has partaken freely of fluids like beer, until the stomach shall have been emptied, either by an emetic or by means of the stomach tube, as the risk of inspiration of large fragments of food or quantities of fluid cannot be ignored. In like manner, when fecal matter is present in the stomach, even an operation for intestinal obstruction, strangulated hernia, or appendicitis should be delayed until a stomach tube can be introduced into the organ and its cavity thoroughly washed out. This precaution will both obviate drowning by inspiration of the stomach contents and will diminish the chances of toxæmia and prolonged vomiting.

The administration of a general anæsthetic is more than ordinarily dangerous when only one recurrent laryngeal nerve is paralyzed; and, when both nerves are partially involved, as they often are in goitre, the danger is greatly increased, for the paralysis is likely then to become complete under anæsthesia, *i.e.*, inspiration will be suddenly arrested. Even when such patients take the anæsthetic quietly, the sudden falling back of the head when the patient is lifted upon the operating table will sometimes bring on dangerous interference with respiration. It will readily be understood how such a movement of the head may produce this effect, when it is remembered that the muscles of the neck, thus put upon the stretch, cause the goitrous tumor to exert a dangerous degree of pressure upon the recurrent nerves. It is for these reasons that in some cases of thyroidectomy the employment of local anæsthesia should be given the preference. (See also the article on "General Anæsthetics" in the present volume.)

The Environment.—Under the caption of environment, inadequate preparation of the patient and the field of operation can best be considered. The environment of both patient and surgeon is worthy of most careful consideration. For example, take a penetrating bullet wound of the abdomen received in civil life. The patient is usually within reach of a well-equipped hospital with all the means of securing asepsis, efficient nurses, good assistants, and often an exceptionally experienced surgeon. The patient is seen only a short time after being injured, before serious extravasation of the contents of any wounded hollow viscus has taken place, or severe intra-abdominal loss of blood has occurred. Under such circumstances, with the presumable character of the visceral wounds inflicted by a soft-lead ball, and the strong probability that the missile has carried in fragments of infected clothing, an imperative necessity exists for exploration of the ball tract by the knife, *not the probe*, and, peritoneal perforation having been demonstrated, a laparotomy is demanded. The probable success of such intervention is great, much greater than can be secured by delay, which often can only culminate fatally. It is, however, wise to consider the conditions usually obtaining at the dressing or ambulance station on the battle-field, where the possibility of securing proper asepsis, assistance, and a skilled operator is more doubtful. Moreover, there are, at such a station, numerous pressing cases, in which immediate attention will certainly avail, while in that of the abdominal injury it may eventually be found that a laparotomy was really not absolutely needed, or the operation may prove ineffective even when indicated. Then again, even if the patient should be carried to a field hospital, the probabilities are that, by the time when it is possible to perform the operation, the special benefit belonging to an early laparotomy—*i.e.*, the prevention of infection and the arrest of serious bleeding before fatal effusion shall have occurred—will no longer be obtainable. Similar conditions often exist in civil practice, as when the patient's environment is such that he cannot receive adequate attention, and when peritonitis has been permitted to gain considerable headway. While no environment need necessarily deter an expert, unfavorable environment often serves to hold even such a one back from operating, except in the presence of serious internal hemorrhage. The writer does not deny that in exceptional cases success is attained by operating for abdominal gunshot wounds under the most unpromising conditions. It is urged, however, that, except when the patient seems in danger of perishing from a serious hemorrhage unless an immediate operation be performed, it is rarely possible to do any good by a hasty laparotomy, especially if the operator lack experience, if adequate assistance cannot be secured, and if the environment be unfavorable in other respects; and the contra-indications assume an almost positive character if there is reason to believe that the time for preventive laparotomy has passed by.

Some cases of visceral wounds, especially from jacketed bullets, will recover by nature's efforts, while, if a late operation be attempted, there is danger that protective adhesions will be broken up and that infective material will be widely distributed; in other words, that nothing but harm will result from the interference. Other illustrations of the contra-indications resulting from environment will be furnished later.

Although emergency abdominal and cranial operations are often successfully performed, in the absence of what is usually considered adequate preparation of the patient and the field of operation, no one will maintain that, when possible, especial care should not be exercised in this class, or indeed in any class, of cases. Those who rarely have a fatality except from shock or hemorrhage are those who expend most time and care upon these points, especially when intracranial operations are concerned. When proposing to operate for the removal of a brain tumor, for the relief of epilepsy, etc., at least forty-eight hours are required to render the scalp fairly aseptic, and in the case of abdominal operations it is better to begin the local preparations the day before. Those who have had an extensive experience with breast amputations recognize that inadequate disinfection of the axilla usually results in most serious infection of the wound. This is due to the presence, in this locality, of a large number of sebaceous glands, which render the parts so greasy as to make mechanical removal of germs difficult and to render inert such germicidal substances as mercuric bichloride. If a surgeon who has operated under both modes of procedure will compare the results obtained under the earlier régime, with those which he now secures after thoroughly sterilizing the axilla as well as the immediate field of operation, he will readily become convinced of the advantages of a painstaking effort to obtain asepsis. Exceptional skill, ample assistance, and a favorable condition of the patient apparently sometimes disprove the statements just made, but "exceptions only prove the rule." The inability to secure proper preparation of the field of operation should in many instances be at least a temporary contra-indication to operation.

The Personal Qualifications of the Operator and Assistants.—There are certain operations which demand unusual mechanical dexterity and, even more than this, a large experience in general surgical work. These qualifications render an operator resourceful in expedients to overcome unforeseen difficulties. Such operations should not be attempted by one who lacks experience, especially as they nearly always may be deferred until a competent surgeon can be secured. Still further, if the operator be inexperienced, the contra-indication is rendered more imperative if there be at the same time a lack of skilful and experienced assistants. The ease and certainty with which the most difficult operations are completed by the experienced operator, when aided by skilled assistants, stand in marked contrast with the partial or complete failure which is apt to result when the opposite conditions prevail. It is not maintained that only experts in a given class of operations are able to perform them satisfactorily, although it is desirable, when possible, to obtain the services of such men; but it is contended that a man who attempts a new and troublesome operation should have had sufficient experience in other classes of operative cases to fit him to deal with unexpected obstacles, and that he should be so much a master of operative technique that, without specific knowledge of how others have coped with difficulties, he may be able promptly to recognize in what respects the expedients which he has been wont to employ in analogous emergencies in other kinds of operations should be modified in order successfully to cope with the new conditions. In other words, he should have demonstrated, by repeated victories over difficulties, that if he meets with new ones he will be able to overcome them; or else he should withhold his hand. Unquestionably surgery and humanity would both profit if this kind of contra-indication were more generally recognized.

Operating in Two or More Stages.—Although it will be impossible to indicate specifically all instances where completing an operation in one sitting is contra-indicated, a few examples can be given which should serve as a guide to any operator who possesses, to a moderate degree, surgical instinct. There may arise, during almost any operation, circumstances which contra-indicate further interference, and it should be distinctly understood that it is good surgical practice to have "a living patient rather than an ideally complete operation." Various conditions have been generally accepted by surgeons as contra-indications to completing an operation at one sitting, and some of these will be mentioned here. For example, it has long been recognized in plastic work that the attempt to slide flaps too far will often result in their failure to unite, or will lead to necrosis of the stretched parts; while, on the other hand, if they are shifted only a moderate distance, they will live and will unite with the deeper parts, and may then be successfully slid further at subsequent operations, until finally an ideal result is secured instead of a failure. Again, if a liver abscess occupying the upper surface of the liver has to be dealt with, it is sometimes impossible to reach it except through the diaphragm, thus opening the pleural cavity. Under these circumstances infection of the serous membrane can be avoided by one of two procedures, viz., by primary suturing of the parietal pleura to the diaphragmatic pleura, thus shutting off the thoracic cavity; or, where this is impossible, or not likely to prove secure, by the use of a tamponade for as long a time as possible, to secure occlusion by the formation of adhesions, when the pus can be safely evacuated. A similar procedure can sometimes be adopted when the abscess has to be opened through the peritoneal cavity. Lung abscesses without adhesions between the parietal and pulmonary pleuræ can be handled safely by the two-stage operation; and the same mode of procedure may be employed for the extraction of lodged foreign bodies. In patients much reduced in vigor, empyemata are often best treated by intercostal incision and drainage until such time as they are able to bear thoracoplasty. Moreover, the area of the thoracic walls which must be rendered flexible can be better determined by the extent to which the cavity has been obliterated, after the lapse of time requisite to fit the patient for the major operation.

Another example of the wisdom of doing the work in two stages is furnished by the operation for extirpating the semilunar ganglion. In this operation the hemorrhage is sometimes so profuse as either to endanger the patient's life or to obscure the field of operation to such a degree that the procedure cannot safely be completed. Under such circumstances the operation may be stopped and the wound tamponed. After the lapse of several days it will be practicable to remove the ganglion without further hemorrhage of any moment. In many other classes of cases in which the occurrence of hemorrhage requires tamponade, or in which there is some doubt as to the completeness of the asepsis, it is impossible, or unwise, to attempt to secure primary union. Under such circumstances one may resort later to "secondary suture," by means of which healing may often be secured quite as rapidly as in cases of primary suturing.

In some cases of carcinoma of the tongue the condition of the patient appears to forbid removing at one sitting both the diseased organ and the secondary growths in the neck. Under these circumstances a secondary operation can be done later with excellent results. Indeed, during such operations conditions may occasionally arise, even in the robust, which should induce the prudent surgeon to postpone clearing the neck to some future time. Although theoretically such operations should be completed at one sitting, it is sometimes better to postpone their completion until the patient has rallied from the first intervention. In some prostatics of advanced age, with seriously infected bladders, success can be attained only by a preliminary drainage of the bladder before proceding to remove the prostate.

Medico-legal Considerations.—The absence of legal consent to an operation at times serves as a contra-indication. That which follows is the opinion given by a distinguished lawyer; the subject will be fully treated in Vol. VIII.:

> In case of a surgical operation upon a wife, it is *always desirable* to get the consent of the husband. If the operation is a dangerous one and may be followed by disastrous results, it is advisable to procure the husband's consent if it can be done without danger to the patient through delay necessary for that purpose. If the operation must take place at once in order to save life or prevent disastrous results, and there is no time for getting the consent of the husband, the operator may undoubtedly proceed with the consent of the wife if she is in condition to give consent. The husband cannot arbitrarily and unreasonably withhold his consent. And if it is apparent that an operation is absolutely necessary and the wife desires it, the operator may certainly proceed without consent of the husband. A husband has no right to imperil the life of his wife by withholding his consent to an operation if it is apparent that it should take place. Consent of the wife to an operation upon the husband is not probably necessary, although it could do no harm to obtain it, and if it can be done without special trouble it is advisable that it be obtained.
>
> Ordinarily, in case of an operation upon a minor, the consent of the parent or guardian should be obtained, although if the operation is necessary and consent cannot readily be obtained, and if the minor has arrived at years of discretion and understanding, his consent probably would be regarded as sufficient.

Vascular Apparatus.—The briefest study of the physiology of the vascular apparatus will demonstrate beyond all cavil that upon its integrity depends much of the success or failure of operations. Upon the proper maintenance of nutrition depends not only health, but also the power of the tissue cells successfully to cope with an invasion of the germs of infection—either by preventing them from securing a lodgment in the body or by gaining the final victory over them after they have secured such lodgment and have begun to multiply. Still further, upon the normal nutrition of the blood-making and digestive organs one must rely for the restoration of blood losses and the maintenance of the quality of the blood, upon both of which depends the recovery of any patient who is subjected to exhausting and prolonged wound discharges. This depletion occurs after certain operations in spite of modern wound treatment. A moment's reflection will also convince one that proper nutrition depends upon a normal condition of the vascular supply to the tissues.

When an operation interferes much with the direct arterial supply, let us say, to one or both sides of the brain, as in ligation of one or both common carotids, or entails the interruption of the main blood supply to the lower extremity, as when a popliteal aneurism is extirpated, the proper nutrition of the brain or limb respectively will depend upon the rapidity and extent of the development of the collateral vessels. The readiness with which this development of the small vessels takes place, and the large size which these arterial channels attain, are phenomena which depend on the physical conditions of the vascular system. If they are to occur, the collateral vessels should either retain their normal dilatability under increase of intravascular pressure or they should not fall far short of this, and the heart muscle should also possess normal or nearly normal power of supplying a *vis a tergo,* thus compelling the vessels to dilate to a sufficient degree. Conversely, arteriosclerosis with its common accompaniment, a related change in the heart muscle, too often contributes to cerebral softening or gangrene of the limb when the direct arterial supply is interrupted. A just estimate of the inadequate dilatability of the collateral vessels, in the class of cases mentioned, will often enable the surgeon to secure success, or at least to avoid disaster, by adopting measures which take account of this defect. Thus, for example, in the case of an aneurism it is wise not to attempt the extirpation of the aneurismal sac, for fear that the damage done to the tissues through which the collateral circulation will have to be carried on may imperil the integrity of the anastomosing vessels. Again, in low leg amputations for senile gangrene a recurrence of the disease is the rule, while in a few cases the limb will retain its vitality for a distance below the knee, as illustrated by attempts at spontaneous separation below the tubercle of the tibia. In such cases the collateral branches anastomosing with the profunda possess sufficient elasticity to admit of a fair blood supply to the tissues, and an amputation below the knee may, therefore, under these circumstances, succeed. Still further, if the limb is removed at the junction of the lower and middle thirds of the thigh the flaps will usually retain their vitality and healing will be promptly effected. This is easily explicable. The sclerosed vessels are often thrombosed as high up as the groin, or the popliteal is at least blocked throughout the whole of its course; hence the flaps of a low leg amputation, depending for their nutrition solely upon the establishment of a collateral circulation, which the rigid condition of the small vessels prevents, perish, while the flaps of a thigh amputation retain their vitality, owing to the fact that they receive their blood supply directly from the patent profunda and its branches. The question whether to amputate or not, in cases of compound fracture of a limb, may depend more upon the integrity of the patient's heart and arteries than on all the other conditions combined. In deciding the question of amputation, therefore, in cases of traumatism, the surgeon should have for his guiding principle the adequateness of the blood supply to the parts distal to the seat of the open (compound) fracture. If all, or nearly all, the direct arterial supply be cut off by occlusion of the main vessels, the nutrition of the member will be supplied solely by the collateral circulation. This being the fact, these questions present themselves: Are the soft tissues which contain the anastomosing vessels sufficiently intact to serve the purpose of furnishing an adequate collateral circulation? and, Is the heart's action equal to the purpose? Should there be any doubt in regard to these matters it is of prime importance to ascertain whether or not the establishment of a proper collateral circulation is likely to be interfered with through strangulation of the anastomosing vessels by inflammatory exudate. Hence the further importance of estimating the degree of prospective infection. If no such obstacles to the establishment of a collateral circulation are likely to arise, there is a strong probability that the attempt to save the limb will succeed. On the other hand, if severe inflammation is likely to develop, it may be assumed that the small blood-vessels will then be compressed by the inflammatory exudate and that gangrene will almost certainly occur. Under these circumstances, therefore, amputation would prove to be the better practice. Still other questions are likely to arise. Will the damaged tissues receive even enough pabulum to limit the spread of the infection, so that, although limited death of the part results, somatic death may be avoided; or will the patient probably succumb to the systemic infection if the limb be not removed? If, in a given instance, all the preceding queries have been favorably answered, there will still remain for consideration the question, Does the probable, or even the certain, future degree of usefulness of the member warrant the necessarily greater risk to life of so-called conservatism as compared with amputation? This question must be carefully considered, especially where much bone has already been destroyed or is almost sure to perish from a severe degree of infection. The difficulty of maintaining the general nutrition in the very young or the very old, particularly when prolonged suppuration follows conservative delay; the risk of prolonged confinement in the case of the aged; the greater necessity of saving the limb in the case of a laboring man than in that of a well-to-do person; the loss of time and wages entailed in preserving a crippled limb for a laboring man; and possibly other unfavorable circumstances, are often significant contributory factors in deciding for or against amputation for injury.

As it is said, "We are no older than our blood-vessels"; hence the influence of "old age," from the operative standpoint, should be gauged by the degree of degenerative changes present in the heart and arteries. Degenerative vascular changes are sometimes present to an extreme degree in those who have not yet reached middle age. Although it is not unusual to find that the blood-vessels of those of advanced years have undergone serious degeneration, still such changes may be but slightly marked in the old. Arteriosclerosis causes not only impaired nutrition and consequent loss of tissue-resistance, but also, directly or indirectly, a lessening of the power to regenerate blood, which latter feature often renders hemorrhage dangerous in the old. Nevertheless, many patients who are old in years have relatively young vessels, and their powers of digestion and assimilation, and of regenerating blood, are preserved. Under such conditions the elderly patient may prove as good an operative risk as a man of twenty years. (See article on "General Surgical Prognosis" in Vol. I.)

Infants and young children do not bear well the loss of blood. During infancy and early childhood the blood- and tissue-regenerative powers are usually adequate, but, after comparatively small losses of blood, shock is often marked and of prolonged duration. In some cases death may even follow, owing mainly to the fact that the cerebro-spinal and the vasomotor systems, upon whose proper functioning life depends, are deprived of adequate pabulum for so long a period of time. This lethal result may depend in part on the actual lessening of the bulk and quality of the blood by the hemorrhage, and in part on the diversion of blood into the capacious abdominal vessels, enlarged to their fullest capacity through vasomotor paralysis. (See "Surgical Shock," p. 463, Vol. I.) It must therefore be remembered that, while severe losses of blood may prove serious in operations upon individuals of all ages, these losses are specially dangerous in the case of the very young. Consequently, when there is a choice between an operation entailing much hemorrhage and one where the bleeding will be slight, the latter should be chosen when practicable, and strict precautions should be taken to prevent the untoward effects of the loss of blood which may happen during the selected operation. The author has seen an infant's life greatly and needlessly imperilled after operation for uncomplicated hare-lip, from uncontrolled bleeding.

The Heart.—As has already been intimated, chronic myocarditis and its results often coincide with arterial degeneration. It is of great moment to the patient and to the reputation of the profession for wisdom that the unfavorable influence of this condition be properly estimated, not only because of its possible effect upon the result of the operation itself, but also on account of the increased risk attending the administration of a general anæsthetic to a person thus affected. It is under circumstances like these that the question of employing local, infiltration, or spinal anæsthesia can be properly considered. Fatty degeneration of the heart is also a serious condition, and, if well marked, should be viewed as a contra-indication to any operation of complaisance. It is only when the indications for operative interference are urgent that the surgeon is justified in disregarding this condition of the organ; and, if the case is one in which a general anæsthetic must be employed, chloroform should not be selected. (See article on "General Anæsthetics" in this volume.) Changes in the myocardium which are well compensated and which are not associated with imperfectly performed renal functions do not seem to influence unfavorably the course of a carefully administered general anæsthesia, or the subsequent well-being of the patient. Relatively young patients who have structural changes in the myocardium and also arteriosclerosis, and who have at the same time bronchitis or pulmonary emphysema, are liable to serious primary or secondary heart failure in chloroform narcosis. In this class of cases local or spinal anæsthesia should be employed if practicable, instead of a general anæsthesia. Valvular cardiac lesions which are well compensated need not interfere with necessary operative intervention, but lack of compensation may lead to serious consequences at the time of operation, and later may indirectly interfere with proper recovery and efficient repair. Although this rarely happens, acute dilatation of the heart may complicate an attack of acute appendicitis. In such a case as this the operation should, if possible, be postponed until the condition of the heart can be improved. Furthermore, if under these conditions perforation has occurred a general anæsthetic should, if possible, not be employed, but instead resort should be had to local anæsthesia; and the operation should be limited to that which is absolutely essential to save life.

The importance of ascertaining the condition of the heart, chiefly by a determination of the vascular pressure, has been emphasized by Kocher when considering thyroidectomy, especially for exophthalmic goitre. Kocher, who has completed more than three thousand operations for all forms of goitre, insists that even such a slight lowering of the blood pressure as 20 mm. below the normal renders thyroidectomy "somewhat hazardous," while the presence of the cardiac insufficiency of a marked "goitre heart," which is so often seen in advanced exophthalmic goitre, should, in his judgment, serve as a distinct contra-indication to thyroidectomy.

The effect of general anæmia upon the heart, with its possibilities of dilatation, should not be overlooked; this complication, however, will be dwelt on later under another caption.

The Gastro-Intestinal Apparatus.—Although at the present time the condition of the digestive organs less frequently plays the prominent part in the recovery or death of the patient than it did formerly, when severe losses of blood resulted from operations, and suppuration (often most profuse) was the rule, yet the possibility that both may attend upon modern operative intervention renders it advisable to give heed to the condition of the gastro-intestinal functions. It should also not be forgotten that perverted digestion may lead to the formation of imperfectly elaborated substances which the liver and kidneys, perhaps already crippled, cannot eliminate, and that auto-intoxication, from intestinal sepsis, may add its deleterious influence to that of germ infection. Due consideration of these facts will often lead to preparatory and later treatment which will avert harmful results that might otherwise turn the scale against recovery. The success of many of the older surgeons, despite their ignorance of antisepsis and asepsis, was unquestionably due in large measure to their recognition of the evil effects of conditions which we now recognize as auto-intoxication and intestinal sepsis, to the care with which they prepared their patients for operation and regulated their diet, and finally to the efforts which they made to secure elimination of morbific agents.

Persistent and otherwise unexplained diarrhœa in those suffering from prolonged suppuration, especially when the latter arises from chronic bone or joint lesions, should arouse suspicions as to the presence of commencing amyloid disease of the intestinal vessels. If, in addition, the liver be enlarged and albumin with amyloid casts be present in the urine, the suspicions should give place to practical certainty, and should encourage the doing of surgical procedures calculated to lessen or arrest the causative suppuration. Under these circumstances, therefore, amputation may be done rather than excision or the erasion of a joint; and the amyloid change, which ordinarily might be considered a contra-indication to operation, presents an indication for active intervention, since by this means the suppurating tissues will be promptly eliminated. The beneficial results are often strikingly noticeable in children, in whom subsidence of an enlarged liver and amelioration of the other symptoms sometimes promptly follow the removal of a suppurating area.

The Genito-Urinary Apparatus.—The question of proper elimination is intimately related to that of a normally functioning gastro-intestinal tract. It is a common practice to scrutinize the urine for albumin and sugar, and also to search for the possible presence of renal tube casts, but how seldom it is that a careful estimate is made of the quantity and quality of the solids of the urine, even before operations on the kidney. Such an examination may often show the quite certain failure of a radical operation because of renal insufficiency, although it may be possible to adopt some palliative measure until more favorable conditions are established. Special difficulties sometimes arise after the administration of a general anæsthetic to a patient in whom the urinary solids are abnormally excreted; and, when the latter fact is known, it is advisable, if time permit, to correct all such deviations from the normal by careful preparatory treatment. Albumin in the urine may mean nothing serious, but, when demonstrably of diseased renal origin, it should raise the question of the propriety of employing local instead of general anæsthesia, and, if this latter form must be used, the anæsthetizing agent should be cautiously administered and restricted to the minimum amount. Sugar in the urine must be proven to be due to diabetes before any steps are taken to treat the condition as an unfavorable one in itself, because sometimes, although rarely, it is of septic origin and indicates rather than contra-indicates operation, especially when the contemplated procedure removes the source of the infection. Again, when genuine diabetes is present, if delay is permissible, proper dietetic and medicinal treatment may be undertaken, as this will often greatly lessen the quantity of sugar excreted, thereby diminishing the predisposition to infection and the evil effects which the latter exerts upon tissue repair. Unquestionably, diabetic sugar in the tissue fluids renders them a better microbic culture medium, although, if asepsis is maintained, this risk is removed. The possibility of avoiding a sudden and possibly fatal attack of diabetic coma, due to the combined effect of the operation and the anæsthetic, can usually be averted by preliminary treatment.

The question as to the increased dangers attending the use of general anæsthetics, and the performance of operations in those in whose urine acetone is detected, is still a mooted one. Some contend that when this condition exists *before* anæsthesia the acetonuria is not increased nor does other harm result. It would be certainly wiser, however, when possible, to remove this condition before operation.

Although menstruation is no bar to operations of immediate urgency, yet it is undesirable to operate during or just before the advent of a period. The disturbances then often experienced are apt to be exaggerated and they sometimes obscure the true condition of the post-operative course.

No attempt will be made to give all the contra-indications presented by the diseases and conditions of the genito-urinary system, but it is of importance to recognize that the highest operative success is dependent upon a nice discrimination as to the relative importance of the abnormal conditions present. As an illustration, calculous cystitis cannot be said to contra-indicate lithotrity. Nevertheless, the surgeon should endeavor to estimate whether the cystic inflammation is so advanced that the mere removal of the stone by this operation can scarcely be followed by a return of the bladder to its normal condition. The draining of this viscus which is secured by lithotomy is clearly indicated in such a case; for, if the surgeon places his trust in a simple lithotrity, he may either lose his patient or, if recovery ensues, he may find it necessary, through the failure of that operation to afford any distinct relief, to drain the bladder by a cystotomy; the beneficial results thus obtained demonstrating that a primary lithotomy would have been the better procedure.

Retention of urine from urethral stenoses, such as occur during the acute stages of gonorrhœa, should not be relieved by the catheter, but by the hot sitz bath and morphia; and, if these fail, the best course is to resort to repeated aspirations with a small needle. While this may seem to be heroic treatment, it must be remembered that the almost inevitable cystitis with all its perils, and the damage inflicted upon the swollen, lacerable urethral mucosa by frequent introductions of the catheter, are more dangerous than repeated aspirations.

The Nervous System.—Insanity and diseases of the nervous system should not be considered a bar to necessary operations, especially when the conditions for which they are to be done are dangerous to life or tend to aggravate the nervous condition. On the other hand, the difficulties experienced in controlling the insane, or the incessant muscular contractions of choreic patients, cannot be ignored, and at times may prove insuperable obstacles to operations, even such as would otherwise promise good results. It should also never be forgotten that operations involving the genital apparatus of men or women sometimes precipitate an outbreak of mania or melancholia in patients hitherto sane. Still further, the removal, in the case of young women, of the diseased tubes and ovaries which seem to be the cause of their mental condition at times converts a slight abnormal mental state into one of violent mania. At the same time it is true that, in properly selected cases, much good, if not a cure, results from such an operation. Extreme care, however, must be exercised in making the selection, and the prognosis should be guarded.

Individuals afflicted with insomnia should be viewed with suspicion, as they are very likely to belong to the class of those who indulge in alcohol to excess in private, or to that of the so-called "moderate drinkers," who are never drunk. Individuals belonging to either of these classes may, as the result of the combined effect of the shock of an operation and the withdrawal of their alcohol, develop delirium tremens or a condition of sleeplessness which is a serious obstacle to their recovery. Under such conditions the ingestion and assimilation of food are seriously interfered with, and those who are feeble, or who are subjected to losses of blood and profuse wound discharges, speedily become exhausted.

The period of dentition, especially when several teeth are approaching the surface at the same time but have still considerable tissue to penetrate, is regarded by some as an objectionable time for the performance of any but operations of necessity.

Fear.—It is extremely difficult to determine what weight should be given to the undue fear experienced by some patients concerning a fatal outcome of a proposed operation. Where but little is required to turn the scales toward the side of death, unquestionably fear may sometimes lead to fatal results through psychical shock, through the lack of co-operation of the patient in declining proper nourishment, through loss of sleep, and, finally, through the impaired resistance which results from the combination of all these factors. Such extreme dread as is referred to here should be carefully considered, so that every effort may be made to soothe the fears of the sufferer, as the successful outcome of an operation sometimes materially depends on the tranquillized state of his mind. In cases where the proposed operation is not absolutely necessary, but somewhat a matter of choice, and is in itself perilous to life, the fixed conviction of the patient that recovery will not take place should occasionally be considered as a contra-indication. It is often not the most formidable and dangerous operations which thus terrify patients, and it is not always the hysterical or silly who are the victims of this dread. Psychical shock, although almost never fatal of itself, may readily prove a determining lethal factor in a patient with unsound organs, who is also subjected to the physical shock and loss of blood of an operation.

The Pulmonary Conditions.—In all supposed cases of appendicitis in children a careful examination of the lungs is requisite, as it is now well known that pain and tenderness in the lower right abdomen, with some rigidity of the muscles in the neighborhood, may sometimes be the main initial symptoms in right-sided pneumonia. Both conditions may of course coincide, but a physical exploration of the chest will exclude pneumonia and demonstrate the necessity for a rigid investigation such as will determine the presence of appendicitis.

The question of operating during an acute pulmonary ailment—as, for ininstance, for strangulated hernia—need be considered only so far as the choice of the anæsthetic is concerned. When possible, local or spinal anæsthesia is safer than inhalation anæsthesia, but, should this latter be found to be an absolute necessity, chloroform is to be preferred, in most instances preceded by a proper dose of morphine and atropia. As previously stated, pulmonary emphysema, especially when coinciding with sclerotic changes in the heart muscle and arteries, should receive careful consideration. In such cases the question as to the propriety of any operation naturally arises. If operation be decided upon, a careful choice of the anæsthetic should be made, and the duration of its administration, as well as the amount administered, should be reduced to the minimum.

Nothing that has already been said, or that may be mentioned later, should be interpreted as a positive contra-indication to operations required to save life or the function of an important organ; but, where the necessity for operating is not clear, or where there is a choice between the methods of procedure, the decision should always be in favor of the course which will subject the patient to the least risk. Pulmonary tuberculosis, especially if it be in its earliest stages, often demands the removal of suppurating lymph nodes, the excision of painful, disintegrating, or suppurating tuberculous joints, the evacuation of an empyema, etc., all of which conditions are a serious drain upon the patient's strength. Only such operative measures should be adopted as will effect relief of the local condition with the minimum of confinement to bed or the house, and without entailing any serious degree of suppuration. The importance of this rests upon the fact that pulmonary tuberculosis is often curable if the debilitating effects of other foci can be removed. Hence it is preferable, in cases like those which are now under consideration, not to resort to an excision or to erasion of a suppurating joint or a joint involved in extensive tuberculous changes, but to perform an amputation. Oftentimes, when this course is adopted, cases of incipient pulmonary tuberculosis undergo a permanent cure, and it is not an unusual event for some amelioration of the lung condition to take place even in the more advanced cases. On the other hand, in cases in which the lungs are seriously diseased, and in which death from tuberculosis is a mere matter of time, only the minor surgical procedures, which can be effected under the influence of local anæsthetics, are permissible. Even these minor operations should not be thoughtlessly undertaken. For instance, the radical operation for fistula in ano is contra-indicated in tuberculous patients with frequent cough or with violent paroxysms of coughing, even if the latter be infrequent. This injunction is given, not because the lesion is necessarily one of a tuberculous nature, for it is often of purely pyogenic origin, but because the cough usually so interferes with the healing of the wound that, instead of checking the purulent discharge and lessening the pain, both are increased. On the other hand, when, in these tuberculous cases, the cough is so slight that it will not interfere with healing, the cure of an anal fistula should certainly be attempted, because it will remove a source of depression of the vital powers. At the same time it is desirable, as has already been stated, that the operation should be performed with the aid of local anæsthesia and in a case in which there is reasonable ground for believing that the local lesion is not of a tuberculous nature. There are some exceptional cases—cases in which the pulmonary lesions are not of a serious nature—in which it is of distinct importance to operate for the relief of a fistula or of some other condition that is reducing the patient's general vital resistance—as, for example, caseating and suppurating lymph nodes. In such cases, which must be selected with care, a general anæsthetic may be employed whenever it is impossible to secure the consent of the patient to an operation under local anæsthesia. The administration of nitrous oxide gas as the first step in anæsthetization by ether or chloroform is contra-indicated in the presence of acute pulmonary diseases, and is of doubtful propriety in pulmonary tuberculosis or in chronic bronchitis, because this agent produces venous congestion.

Some individuals have chronic coughs which are at times violent and paroxysmal. These patients are bad subjects for such operations as the radical one for hernia, nephrorrhaphy, interval operations for appendicitis, etc. If local or spinal anæsthesia can be made to suffice in this class of cases, the lung condition, *per se*, will present no obstacle. The disturbance to which the healing of the wound is subjected by the repeated mechanical effects of the coughing should be carefully weighed by the surgeon before he decides upon any of these operations. (See also the article on "General Anæsthetics" in the present volume.)

The Blood.—Changes in the composition or behavior of the blood are of great import to the surgeon when contemplating any operation. (See also page 555 *et seq.*, Vol. I.) In the front rank stands the question of hæmophilia. Thus far, no method of examination has certainly revealed the cause of this malady, although recently one observer has been able to predict an approaching hemorrhage by the lessening or absence of the blood plates. Whether the puncture made for the purpose of securing the blood for this examination might not prove a source of danger is a question which merits consideration. Inquiries directed to determining the behavior of slight wounds, the sudden appearance of accumulations of fluid in the large joints (*i.e.*, hæmarthrosis), or the character of bleeding after tooth extraction, will usually settle the question harmlessly. The tendency to persistent oozing, which is observed in some forms of sepsis, is something quite different from hæmophilia; it cannot be foreseen and consequently it is impossible to guard against it. The severe and usually fatal bleedings which sometimes follow operations (especially those involving the biliary apparatus) in persons who are affected with chronic jaundice, may easily be accounted for by the damage inflicted upon the blood-vessels through the presence, in the circulating blood, of biliary salts, and also in some measure through the withdrawal, from the cells of the intima, of their proper pabulum, from blood impoverishment; many of the red corpuscles being destroyed in cases such as are here under consideration. The intimal cells cannot derive nourishment *directly* from the blood-cells, but the lack of oxygen, the failure to change excreta, etc., which characterize these cases, so interfere with the nourishing qualities of the blood that the intimal cells suffer. The possibility of such severe bleeding should be carefully weighed before one decides to operate on a severely jaundiced patient, and all measures should be employed which are believed to lessen this hemorrhagic tendency, although only a small proportion of icteric patients bleed unduly. Possibly the finding of occult blood in the stools—a thing which has been frequently accomplished—may be of value in determining the probability of dangerous hemorrhage after operation. Without a sufficiency of hæmoglobin, despite a fair number of red cells, life cannot be long maintained; hence a determination of this point is essential in those patients in whom this important blood constituent may have been reduced by previous hemorrhage or a prolonged purulent drain. Discrimination must be made between the low hæmoglobin content which results from severe losses of blood in a previously healthy person, especially if a female, and the deficiency of this substance which results from some exhausting disease that may have permanently impaired the function of the organs concerned in the reproduction of the blood. In the former instance, the regenerative powers may be so great that even a further lowering of the amount of hæmoglobin may be readily recovered from, while in the latter the reformation of this element takes place so slowly and is so uncertain that death often results. It is stated that twenty per cent of hæmoglobin is essential to sustain life, and that less than this is incompatible with survival. This is doubtless usually true except when the reduction has been sudden and has occurred in a person with normal blood-making organs; even then recovery is uncertain. Those individuals who possess as much as thirty per cent bear loss of blood badly; hence, if after appropriate treatment the amount of hæmoglobin cannot be increased, no unnecessary loss of blood should be permitted and only the minimum amount of a general anæsthetic should be administered. The latter injunction applies especially to chloroform, although ether is also a hæmolytic agent. It must not be forgotten, when estimating hæmoglobin by the usual clinical methods, that an error of at least five per cent (either plus or minus) is possible. In other words, the patient may really possess more hæmoglobin than is reported, thus explaining the conflicting statements which have been made as to recovery taking place with an extremely low hæmoglobin index.

The detection in the blood of evidences of either splenic or lymphatic leukæmia should contra-indicate, in the former, the operation of removing the spleen, and, in the latter, all operations not demanded for the immediate salvation of life. This course is rendered necessary by the difficulty or impossibility of arresting hemorrhage. It is contended by some that hemorrhage is only to be feared in profoundly anæmic children who are affected with acute lymphatic leukæmia, but the advice given above had better be adhered to in all cases. It is interesting to note that in Banti's disease, where no such blood changes are present, removal of the spleen presents no difficulties from bleeding.

Anæmia, however induced, unquestionably increases the risk of infection after operation; hence its presence or absence should be determined, and its possible influence on the outcome of the intervention should be carefully weighed when any serious operative procedure is contemplated.

Through deficient nutrition the heart muscle may dilate under the stress of the increased frequency with which it must contract in order to carry oxygen to the tissues—an increased frequency which is necessitated by the scarcity of oxygen-carriers, viz., red cells and hæmoglobin. The maintenance of accelerated heart contractions may exhaust a fairly strong heart muscle, which may then finally yield to the intracardiac pressure. Although this is a rare accident, the fact that acute dilatation of the heart may possibly occur in an anæmic individual when subjected to a severe operation, especially if it be accompanied by considerable loss of blood, should be more widely known, in order that precautionary measures may be taken. Chloroform especially and ether somewhat increase the pre-existing anæmia by effecting a destruction of numbers of red blood cells, thus accentuating the effects of loss of blood during operation. The rapid pulse-rate, conjoined with the loss of vascular tone in the class of cases mentioned above, sometimes determines the development of acute dilatation. But forewarned should be forearmed, so that a strict avoidance of all unnecessary loss of blood during operations on anæmic individuals, in conjunction with the administration of appropriate heart tonics, will probably, in the exceptional cases in which this condition would otherwise occur, avert the risk of the development of an "anæmic heart" with all its untoward consequences. Of equal importance is the avoidance of all strain upon the heart for a certain period of time after the operation; a precaution which must be observed not only until the anæmic condition is relieved, but also until the heart muscle has recovered its normal nutrition.

Malaria.—Although malaria is of more unusual occurrence than was formerly believed, there are nevertheless cases in which it has to be reckoned with by the surgeon. Anything, such as an operation, which markedly reduces vital resistance, may provoke an outbreak of malarial fever in one who at some previous time has suffered from the disease or who has recently resided or still resides in a malarial district. An examination of the blood may reveal the presence of the plasmodium, which might, without the reinforcement of the depressing effects of an operation, continue to remain dormant. The failure to detect malarial organisms in suspicious cases may be due to their small number, to the fact that they are, as believed by some, temporarily stored up in the spleen or bone medulla, or to the effects of quinine taken as a prophylactic. Unquestionably, patients with the lowered resistance often left by an operation readily succumb to a slight plasmodial infection if they are living in a malarial neighborhood. An examination of the blood will often show much pigment and poikilocytosis, with deficient hæmoglobin, in cases in which, after operation, there develop malarial paroxysms which up to that time have been held in check by quinine. Such blood-findings should always be regarded as suspicious, but the exhibition of the proper amount of quinine should remove all possible chance of an outbreak. While only active malaria is a contra-indication to operations of choice, but not to operations of necessity, yet a severe malarial attack after an important operation might seriously jeopardize the life of the patient or the success of the procedure. It is therefore advisable, when an operation is contemplated, to determine beforehand the probable advent of malarial disease, and to take whatever precautionary measures may be advisable.

Other Infectious Diseases.—Acute infectious diseases such as typhoid fever, and also certain normal conditions, as pregnancy, have sometimes been considered as positive contra-indications even to urgent operations. In the case of a pregnant woman, for example, the performance of any fairly serious operation, it is thought, will almost certainly involve miscarriage or premature delivery; moreover, the chances of fatal operative or puerperal infection are believed to be, under these conditions, exceptionally great. Appendicitis occurs during typhoid fever or pregnancy with sufficient frequency to render it important to decide whether the prevalent belief is well grounded or not. While no one would choose to operate upon a typhoid patient or a pregnant woman, yet abdominal sections in typhoid—made, it is assumed, for imperative reasons—probably present no more unfavorable conditions than does the same state of the circulation, nutrition, etc., when brought about by some other cause. Suppurative appendicitis, strangulated hernia, an ovarian tumor with tightly twisted pedicle producing gangrene, acute suppurative cholecystitis, and other serious conditions may be complicated by pregnancy, yet they must be dealt with irrespective of the latter; and when fatal results follow or a miscarriage results, there is no conclusive proof that the operation precipitated the fatal or unfortunate outcome. Probably the reverse is the truth, since disaster is certain in some of the conditions mentioned and recovery possible only by operation.

Operations Performed for Cosmetic Effects.—The uncertainty of the outcome of many plastic operations, so far as the cosmetic results are concerned, should often debar us from operating, especially if the expectations of the patient or the friends are unwarrantably high. Great care should be exercised not unduly to raise the hopes of any concerned, and the surgeon should convince himself that the patient really comprehends the possibilities, as well as the probabilities, in all the operations performed for cosmetic reasons.

Recurring Malignant Disease.—The presence of metastases that are inoperable should contra-indicate attempts to excise local or regional recidives except when an ulcerating, painful condition is present which can be removed. A reasonable certainty of securing prompt healing should exist, and, even if the results prove only temporary, and if a fresh recurrence of the growth takes place, such interventions are entirely justifiable. Upon the other hand, when there is no evidence of inoperable secondary growths, all recurring malignant neoplasms should be excised as soon as detected. Prolongation of life and increase of mental as well as of physical comfort result from such operations, which may be repeated as often as necessary. In a few instances a cure is brought about by a persevering resort to repeated excisions of minute growths under local anæsthesia. In cases of this character no delay should be permitted, even if nothing more than a well-grounded suspicion of a recidive exists.

THE PREPARATION FOR AN OPERATION, THE OPERATION ITSELF, AND THE CARE OF THE PATIENT DURING AND IMMEDIATELY AFTER THE OPERATION.

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SURGICAL procedures are always undertaken for one of the following objects: First, to save life; second, to relieve suffering; third, to restore function; fourth, to correct a deformity or blemish; and fifth, in rare instances to make a diagnosis in a doubtful condition.

Depending upon circumstances, all operative work may be sharply divided into two classes, deliberate and emergency. By an emergency case one understands a condition calling for immediate operation in the effort to save life. In such an instance the local condition, be it a strangulated hernia or a ruptured ectopic pregnancy, overshadows any general systemic affection that would ordinarily demand care and attention before subjecting the patient to a severe or dangerous operation.

In the field that may be designated as deliberate surgery falls the larger proportion of all surgical procedures, and the success that accrues in a large series of operative cases depends very much upon the careful study of each individual case, and, as has well been said, it is just as important to know what kind of a patient the disease has, as to know what kind of a disease the patient has.

DIAGNOSIS.

The *history*, or anamnesis, often plays a most important rôle in the work of reaching definite conclusions as to the nature of the patient's malady. Some surgeons, in whom the clinical instinct is well developed, seem to have an art of drawing out the essential points in a few minutes' conversation with the patient. Such a course is often fallacious, and it is far better to have a complete history taken by an unbiassed mind, because, when it comes to weighing the sum total of evidence, some seemingly small detail may be found to have a pronounced bearing on the question. The adoption of such a method is a constant incentive to thorough work, a check upon carelessness, and is the means of avoiding the possibility of an oversight.

A detailed history will include: the patient's *complaint;* the *family history* as relates especially to tuberculosis, malignant disease, and mental disorders; the *past history*, which may be conveniently grouped under the headings of infectious diseases, head, cardio-respiratory, gastro-intestinal, genito-urinary, menstrual, marital, weight, etc.; the *present illness*, with inquiries as to date of onset, initial symptom, course of the malady in order of developments, constitutional effects, the present attitude, form and condition of the part involved, past treatment and its bearing on the lesion, etc.

The *physical examination* includes a general examination and a special examination. The notes on the general survey should record the general state of development and nutrition; the color of the skin and mucous membranes, with especial reference to any degree of anæmia, icterus, etc.; the condition of the superficial lymph nodes, with their bearing on any constitutional taint, leukæmia, malignant metastases, and status lymphaticus; the state of the cardio-vascular system, with especial reference to myocardial insufficiency, condition of the arteries, and pulse tension; and the results obtained from an examination of the chest for the detection of bronchitis, emphysema, and the grosser pulmonary lesions, all of which are factors in making choice of the anæsthetic. The abdomen should be examined with regard to tenderness, muscular rigidity, enlargement of spleen and liver, presence of masses of free fluid, and the extremities for nodal thickenings on the long bones, œdema, varicose veins, ulcers, etc. A rectal and a pelvic examination may be indicated as part of the general survey, and in every case attention should be directed to the nervous system in so far as testing the reaction of the pupils and the activity of the reflexes so as to exclude the visceral crises of organic disease of the spinal cord, etc.

The special examination is that directed to the local lesion or seat of pain, injury, deformity, etc. The general examination is often given over to an assistant, or hospital interne, not because it is unimportant, but as a matter of necessity and expediency. The special examination, however, is made by the surgeon who is to operate on the patient; and the extent of this examination, as well as the means employed, will vary with the character of the case and often with the character of the surgeon's thoroughness of detail.

In addition to the general physical findings, further information may be acquired by means of instruments of precision and certain laboratory methods.

The value of special and refined methods of diagnosis depends very largely upon the skill with which they are interpreted. While the diagnosis may be suggested at once by a positive finding, yet in most instances the information so obtained is useful only in adding one or more important symptoms or signs in the given case and so has to be considered along with the history and physical findings in the effort to reach a definite conclusion. (See Vol. I., pp. 501–691.)

PROGNOSIS.

The prognosis in a given surgical case is dependent on many factors, some of which can be appreciated beforehand while others may be obscure. In general, one recognizes the following points:

(1) *Age.* The most favorable period in which surgical procedures can be conducted is between the ages of two and fifteen years; the next, between fifteen and thirty; after thirty the risk increases in proportion to the age, although one constantly encounters exceptions to this general rule. With increasing years come degenerative changes in the heart, kidney, blood-vessels and other tissues, changes which militate against prolonged anæsthesia and extensive wounding of parts and protract convalescence and the repair of the tissues. In spite of the fact, however, that very young children and the aged are not favorable subjects for operations, yet age, in itself, is no real barrier to a necessary operation.

(2) *Sex.* It is generally noted that women withstand operations better than men, and this can be attributed to their spirit of resignation and patience in the presence of pain and confinement as well as to their better habits and mode of life.

(3) *Occupation.* The ill effects of certain occupations upon the general health of the patient must of necessity influence his degree of endurance, and this will show itself when he is subjected to operation.

(4) *Constitutional and Chronic Diseases.* These conditions serve greatly to modify the prognosis, and if they do not absolutely contra-indicate an operation yet they will demand care and attention by the surgeon before the patient is subjected to the strain of the anæsthetic and the operation.

Chronic valvular disease of the heart is not a contra-indication to operation, provided compensation is good. Much more serious, however, are those heart conditions which are associated with myocardial or fatty degeneration, as indicated by a feeble and irregular heart action, cardiac dilatation, and embarrassed circulation. In all heart lesions, however, there is an element of danger from embolism or thrombosis, or from consequent broken compensation and pulmonary œdema. Stenotic valve lesions are generally more serious than simple regurgitations.

Atheroma of the vessels does not contra-indicate operative measures, although a guarded prognosis is often necessary because of the possibility of degenerative changes in the walls of the coronary arteries, and in the vessels of the brain and kidneys, while sloughing may ensue upon wounds of the extremities. Aneurism of the larger arteries does not often influence the prognosis unfavorably.

Chronic nephritis and diabetes seriously modify the prognosis, and the most careful preparatory treatment is demanded in these classes of cases. In both diseases free activity of the bowels, skin, and kidneys is of importance both before and after the operation, and general medical measures should be employed in the effort to forestall the possible occurrence of uræmia or diabetic coma.

Diseases of the lungs, such as acute and chronic bronchitis, emphysema, tuberculosis, and pleurisy, always occasion apprehension as to the successful outcome of surgical procedures. Many persons affected with pulmonary tuberculosis seem to stand the anæsthetic and the operation quite well. The danger of prime importance in all patients with lung complications is the development of a post-operative pneumonia, and for this reason a patient with even a slight "cold" should not be operated upon until the lung condition has cleared up. The question of post-operative pneumonia is dealt with more fully in the section relating to sequelæ and post-operative treatment.

Diseases of the liver and bile-ducts, when associated with jaundice, are among the most serious cases that the surgeon has to deal with. In these instances the cholæmia is almost always accompanied by a marked prolongation in the coagulation time of the blood, so that severe and often fatal capillary hemorrhage ensues. In these cases even the smallest puncture, such for example as is made to obtain a drop of blood from the ear for purposes of study, may bleed for hours. If it is determined that there is complete obstruction of the bile-duct with no other chance of relief, then the patient should be treated with calcium salts, and the operation should be done with as slight traumatism as possible and an abundant amount of packing used. The use of thyroid extract has lately been advocated for the purpose of increasing the coagulability of the blood, and the remedy may be tried. Patients suffering from cirrhosis and from fatty or amyloid degeneration of the liver are poor subjects for operation. In general, it may be said that operation should not be undertaken during an attack of colic, when there is pronounced icterus, when suffering has caused great depression, or if ecchymotic spots are present.

Patients suffering from diseases of the nervous system are commonly not good subjects for operations. Insanity, however, in controllable patients, does not contra-indicate operation unless it takes the form of chronic melancholia with its attendant ill effects upon strength and nutrition. The difficulties connected with the after-treatment of such patients further lessen the chances of recovery. Where there are injuries to the brain or spinal cord, except for the possible immediate relief of these, operation should not be performed. Ataxia, paralysis, and chorea render the patient unsuited for surgical treatment of concomitant conditions.

Tuberculous lesions are quite amenable to operation, and if the diseased material can be removed good healing takes place. In other instances, especially in the presence of visceral tuberculosis, secondary infection often occurs and a discharging sinus remains.

Syphilis is not a contra-indication to operation in any stage, but it is most important that constitutional treatment be administered in conjunction with any surgical procedure.

No operation should be undertaken upon a patient known to be afflicted with the hemorrhagic diathesis unless it can be found possible satisfactorily to increase the coagulability of the blood. Scurvy and leukæmia both contra-indicate an extensive operation, as the wound, in these conditions, is prone to infection and may not heal at all.

Malaria is not a contra-indication to operation, although it is often thought to be a factor in post-operative inflammation and neuralgia. If the patient is known to have malaria it is advisable to postpone the operation for a few days until the rigors are controlled with appropriate medication, and then the infection can be thoroughly eradicated by continued treatment during the period of convalescence. It occasionally happens that a latent malaria becomes active and flares up a few days after operation and so gives the surgeon no little anxiety as to the nature of the manifestation. A careful examination of the blood will usually clear up any doubt in the matter; for, even if the plasmodium is not found, the absence of a polynuclear leucocytosis would speak against sepsis and in favor of malaria.

Only when the necessity for relief of an acute surgical condition is imperative and overriding all other considerations should an operation be undertaken in the presence of erysipelas, and then only under the most rigid antiseptic precautions.

(5) *Habits and Temperament.* There is a distinct danger in performing operations on drunkards that is generally appreciated by all surgeons of experience. Such persons are often affected with degenerative lesions of the heart, kidneys, and liver, their habituation to alcohol tends toward a partial immunity to the effects of ether, so that very large amounts of the anæsthetic are required and the anæsthetist is kept on the *qui vive.* Topers are particularly susceptible to intercurrent infections such as pneumonia, erysipelas, etc.; delirium tremens may also supervene. On the whole, therefore, they form a very undesirable class of surgical patents. (See article on General Surgical Prognosis in Vol. I.)

Overeating is closely allied to intemperance in drinking in increasing the danger of operation. The very obese are not favorable subjects for surgical treatment, as their circulation is usually weak and their vital processes are often below par.

Highly strung neurotic individuals may pass through the ordeals of an operation with surprisingly good behavior, but not infrequently their lack of mental equilibrium is further increased by the general shock to their labile nerve centres and they may pass into various hysterical states at once on coming out from the anæsthetic.

True psychoses rarely ensue upon a surgical operation unless the patient has previously shown definite indications of alienation, but hysterical coma, delirium, etc., may be particularly distressing to the friends and relatives even if it does not annoy the surgeon.

(6) *Various Other Conditions* may serve to modify the prognosis. Severe

operations during the stage of shock after injuries are always hazardous. The clinical picture that gives rise to this bad prognosis is well known, and is shown in the restless tossing about of the patient, who has a subnormal temperature, cold and clammy extremities, anxious facies, and a small rapid pulse.

Pregnancy does not forbid a necessary operation. In the early months many operations can be discreetly performed, and the writer has not infrequently seen fit, under these circumstances, to do interval appendix operations, and the results have been uniformly happy.

Surgical procedures during the menstrual period do not appear in any special way to affect the prognosis. As a matter of comfort and convenience, however, operation is often deferred.

PATIENT.

General Preparation.—In the large majority of cases it is well to avoid prolonged preparatory treatment, for the reason that it is generally not necessary and because the patient is inflicted with the added time in which to anticipate the ordeal. In such instances the mental suffering in the days preceding operation may be more keenly felt than any physical discomfort in the period immediately after. The preparatory treatment demands careful consideration in all cases, but the general indications are few in number and easily carried out.

The patient should be kept in bed and given liquid diet for eighteen hours prior to the operation. Water is freely given by mouth up to within three hours of the time of operation. The practice of withholding water involves unnecessary hardship and discomfort, while its free administration aids materially in the subsequent elimination of ether and is undoubtedly a factor in preventing the liability of shock. In certain cases, such as operative manipulations upon the stomach, it may be inadvisable to give water by mouth. In such instances normal saline solution (250 c.c., or one-half pint) may be administered per rectum two hours before the patient goes on the table.

The intestinal tract should be cleansed and practically emptied before the time of operation. To accomplish this, two ounces of castor oil, most easily taken in a glass of lager beer, are administered about twelve to sixteen hours before operation, and the large bowel is emptied by a soap-suds enema on the morning of the operation. The cleansing of the entire intestinal tract together with the withdrawal of nourishment renders the canal practically sterile in its upper portions, facilitates intra-abdominal manipulation, and lessens the possibility of gaseous distention after the operation. The administration of sterilized foods is also a good procedure; and there are still other plans of action which may be utilized.

If there is nothing in the patient's condition to contra-indicate it, a full warm bath is given the night before operation.

One hour before the administration of the anæsthetic my patients are given morphine gr. $\frac{1}{6}$ to $\frac{1}{4}$ with atropine gr. $\frac{1}{150}$ to $\frac{1}{100}$. This step is taken for the following reasons: First, it increases the confidence of the patient, particularly in nervous cases; second, it lessens the amount of anæsthetic; third, it prevents the excessive accumulation of mucus in the throat; fourth, it reduces the liability to shock; and fifth, the practice of administering these drugs serves a most useful purpose in easing the immediate post-operative pain, while often giving to the patient a happier exit from the influence of the anæsthetic.

It is by such simple general measures as have just been outlined that the patient is enabled in most instances to approach the operation in a satisfactory condition as regards the state of body and mind.

Local Preparation.—Local preparation has to do with the field of operation, and, of course, will vary with the site of the operation. In certain instances very little preparatory treatment of the part can be done, as in work about the nose, throat, and mouth, and in the immediate region of the anus. When plastic operations are to be performed on the vagina, or this route is to be used for certain abdominal work, the vagina should be douched on the evening preceding operation, and again the next morning, with bichloride solution 1 : 2,000 or a half-saturated solution of boric acid, or other mild antiseptic solution. Then immediately before operation, after the patient is anæsthetized, the part should be thoroughly cleansed with the aid of gauze pledgets, sterile water and green soap being first used, and immediately afterward a solution of lysol or other unirritating antiseptic mixture.

Unless it is definitely known that the patient has completely emptied the bladder just before going on the table, the catheter should be employed. This detail should never be overlooked, as it not only gives more room for pelvic manipulation, but also prevents the possibility of wounding the bladder in making an abdominal incision. It should be remembered that even in those instances in which the patient has voided urine just before going to the operating-room one may be surprised at finding a distended bladder on opening the abdomen. In these cases the catheterization will withdraw a large amount of pale limpid urine, the elimination being due to a reflex stimulation of the renal function brought about by nervousness or fright. It is for just this reason that in some clinics it is a routine practice to pass the catheter after the patient is anæsthetized.

The local preparation in cœliotomy cases varies in some small details according to the ideas of individual surgeons. It is universally recognized, however, that the essential point is the thorough cleansing of the field of operation with soap and water.

In order to save a certain amount of time and as a matter of convenience it is customary to do the preliminary preparations the night before operation. At this time the field of operation is shaved, thoroughly washed with green soap and sterile water, and a sterile protective dressing applied which is held in place by a binder. Stiff brushes are commonly employed in this cleansing process, but in the writer's clinic these are discarded in favor of sterile gauze pads or large sponges. This practice has given uniformly satisfactory results and does not cause the pain occasioned by the use of rough brushes on tender skins nor decidedly disturb the normal epidermal micro-organisms.

In some clinics the practice obtains of applying a green-soap poultice which is left on over night. This plan, while effective in its germicidal properties, causes considerable maceration of the epidermis, is uncomfortable for the patient, requires considerable time in its removal just prior to operation, and, in the writer's opinion, is an unnecessary proceeding.

One of the most essential points in preparing the patient for operation is to make sure that the preceding night is a restful one. Any form of treatment which defeats this object is therefore unwise. If the patient is in pain or is particularly nervous, a hypnotic should always be administered.

After the patient is carried to the operating-room the field is finally prepared. This may be done before the administration of the anæsthetic, or after the patient is in position on the table. This cleansing is thoroughly done with green soap and sterile water, followed by alcohol. While it has been repeatedly proved that this relatively simple preparation suffices, yet it is the routine in most clinics further to wash the field with an antiseptic solution, usually a preparation of mercury bichloride, or iodine solution.

It should be distinctly understood, however, and thoroughly impressed upon the surgical assistant, that the essential point in the cleansing process relates to the thorough use of soap and water. Particular attention should be directed to the folds of skin making up the navel, and the cleansing process, including the shaving, should cover a sufficiently wide area to be well beyond the possible actual operative field.

The preliminary preparation is discarded in many hospitals without detrimental effect and it is certainly not a necessary step. Its routine employment is chiefly of value in the matter of saving time.

In certain clinics where a preliminary preparation is not made, the field of operation receives what may be called a double cleaning after the patient is anæsthetized. The first cleaning is done by the nurse or operating-room orderly and consists of shaving the part, and using soap and water, followed by alcohol. Then the second cleaning is done by an assistant who is himself thoroughly cleaned and who generally wears gloves. He uses only aseptic gauze pads or sponges, sterile soap and water, and the antiseptic solution, after which the skin may be dried with alcohol or ether. This assistant then changes his gloves before taking part in the operation.

As soon as the field is finally cleaned the patient's body is covered with a large sterile sheet which has an opening so placed as to be easily adjusted over the operative site. The sheet is further covered with sterile towels which can be easily replaced if much soiled with blood or any discharge. As the opening in the sheet may be unnecessarily large, the exposed operative area may be further confined by placing four sterile towels around the field, two crosswise of the patient's body, and two in a longitudinal direction. These towels are conveniently held in position by means of safety pins. As soon as these coverings are adjusted the field is covered with a sterile gauze pad unless the surgeon is immediately ready for the incision.

The Surgeon and Assistants.

Correct surgical technique is an art acquired only in the school of practical experience. The fundamentals of asepsis may be formulated in the laboratory, the application of these principles may be taught in the class-room and in books, but the practical demonstration takes place at the operating-table. Ideal technique must be reflex. The paths of conductivity between brain and hand must have been worn smooth by use in successful practice, and the slightest irregularity or break in this reflex arc may bring death and destruction in its wake. Nearly all of the special senses are involved in the surgical reflex, and with these the motor and sensory tracts of the surgeon must be carefully co-ordinated and then governed by the higher centre of common sense.

Clothing.—The operating-room and its accoutrements should be a world apart, and for this reason the surgeon and his assistants should not wear any of their usual daily clothes with the possible exception of the underwear. In the dressing-room the operator dons a suit consisting of coat and trousers. These are made of white wash-goods and need not be sterile, but a freshly laundered suit should be used each day. The coat has short sleeves reaching half-way to the elbow, fastens down the back, reaches high in the neck, and below is tucked within the trousers. The feet are clothed in rubber-soled canvas shoes that can be washed when soiled.

Immediately prior to the operation, and after the sterilization of the hands, this suit is completely covered by a white sterile gown, which reaches below the knees, has long sleeves, and is fastened behind. On the head is adjusted a sterile cap. This covers the hair and prevents foreign particles from dropping on to the field of operation when the operator is leaning over the patient.

Further precaution in the matter of dress consists in using masks or shields over the mouth. While in no instance should the operator speak or breathe directly over the wound, yet such a mask effectually confines all emanations from the mouth and should be worn in all operations in which the body cavity is opened. A recent novelty in this line is a combination of mask and cap in the form of a hood. The lower part of this hood is prolonged into a cape which falls about the shoulders, and the only openings in it are those for the eyes and nose. Such a hood is especially valuable in hot weather, as it prevents the possibility of particles of sweat dropping on to the field of operation. The hood is sterilized and should be most carefully adjusted so that the cape does not touch the face when it is put on.

Hands and Gloves.—The preparation of the hands of the operator and of every one who takes part in the operation or in handling the instruments demands most careful and thorough attention. The same scrupulous care should be given the hands whether gloves are to be worn or not. There is a very definite reason for this which should be plainly understood. The skin of the body may harbor many varieties of micro-organisms, and the researches of Welch have shown that a white staphylococcus is constantly present. These organisms get into the hair follicles and mouths of the sweat glands, so that it is practically impossible to dislodge them by mechanical means or to reach them all with any chemical agents that will not at the same time destroy the skin. It is usually possible to render the superficial surface of the skin aseptic, so that infection will rarely be attributable to this source. The avoidance of undue scrubbing and the proper use of gloves are, however, safeguards which the majority of surgeons now heed.

The chief danger in the employment of gloves is that it imparts a false sense of security, so that the cleansing of the hands is slighted. But the gloves may be torn during the operation or pricked with a needle, and then the danger of infection is even greater than if gloves were not being worn. The reason for this is that the hands are prone to sweat within the gloves, and the activity of the skin brings to the surface bacteria from the deeper layers. Therefore in using gloves it must be remembered (1) that the hands should be thoroughly cleansed at the outset, and (2) that a torn glove must be immediately discarded. Extra pairs of gloves already sterilized should be constantly on hand, and with these it is well to have a few sterile finger cots which can be slipped on in the event of a small tear or needle prick.

The *sine qua non* of hand disinfection is soap and water, plus time and elbow grease. To begin with, the hands should be socially clean, then on to the dry skin is rubbed a small lump of green soap. This is thoroughly applied to the hands and to the arms as far up as the elbow, and the process of rubbing is continued until the soap has apparently disappeared. The hands and arms are now immersed in hot sterile water and scrubbed for five minutes with a moderately stiff brush. They are then dried on a sterile towel and each finger nail is carefully gone over with a nail file—a small pointed stick of hard wood is preferred by some—to remove any foreign matter that may be present. The brushes and nail files are kept in a 1 : 30 carbolic-acid solution. A second application of green soap is now made, and the hands and arms are thoroughly scrubbed in sterile water. After rinsing in sterile water the hands should be surgically clean.

This outline of hand disinfection may be variously modified or extended.

In many clinics the routine is much as has just been described, but in addition the hands and arms are soaked in an antiseptic solution, usually 95 per cent alcohol or 1 : 1,000 bichloride solution. Other operators use chloride of lime or potassium permanganate, followed by oxalic acid. It is the writer's opinion that all disinfectants, except soap, are unnecessary, and even as the epoch-making Listerism has given way to modern asepsis so in the smaller details of operative technique have the stronger disinfectants waned in usefulness. Furthermore, the skin that is most readily cleansed is the one that is soft and pliable, and the constant employment of most disinfectants makes the epidermis rough and irregular, even if it does not give rise to a dermatitis.

Rubber gloves are sterilized by boiling for ten minutes. This is best done just prior to the operation, and they are then transferred to a sterile basin containing bichloride-of-mercury solution, 1: 2,000, or simply sterile water. The gloves are easily put on by first filling them with the solution and then pushing the fingers and hand into the distended glove and so displacing the fluid. Some surgeons prefer to put on dry gloves, and in such cases they are dried and kept in sterile talcum powder.

INSTRUMENTS AND SUTURE MATERIAL.

Instruments.—Nearly every form of instrument is so made that it is unharmed by boiling water. All instruments should be kept in a clean dry condition, and just prior to operation they are sterilized by boiling for from twenty to thirty minutes. Knives, however, have their edges injured by such a process and, because of their simple construction, it suffices to boil them for one minute, or they may be sterilized in 1 : 20 carbolic-acid solution.

Soiled non-cutting instruments are cleansed by washing in soap and water and then scrubbing them with a brush and some sapolio or prepared powder. They are then rinsed and boiled in water to which carbonate of soda has been added in the proportion of a tablespoonful of soda to a quart of water. They are then dried and put away in a moisture-free case. If blood-covered instruments are boiled before being cleaned it is found that the albuminous material is firmly coagulated and difficult to dislodge.

Suture Material.—The suture materials most commonly employed are catgut, horsehair, silkworm gut, and celloidin linen. At the discretion of the operator, or for special reasons, metallic sutures of silver wire, silk thread, and kangaroo tendon are all in use.

Catgut is the most extensively employed suture material, and, under favorable conditions, is by far the best substance for the purpose. There are two essential points in the use of this material that must be emphasized, and disappointing results from catgut can always be ascribed to the lack of observance of these two factors. (1) The material must be sterile. (2) The sutures must be drawn and tied not too tightly. As regards the first point it is advisable in hospital work to delegate the sterilization of the catgut to one responsible person who has mastered the technique of the process so as to obtain uniform results. The head nurse of the operating-room is usually best fitted to manage the work. The prepared catgut put on the market by commercial houses is usually satisfactory, but always contains an element of uncertainty as to its aseptic quality. The other essential point in using catgut has been frequently emphasized, but nevertheless is often forgotten. If the suture is tied too tightly, pressure necrosis follows, and, although the gut may be sterile and the wound clean, yet a stitch abscess results. The reason for this is that the injured tissue offers an area of lowered resistance, and a staphylococcus from the skin is able to get a foothold, whereas in healthy tissue it would be quickly destroyed by the protective elements in the lymph, etc.

Catgut is best sterilized by Bartlett's method. Accordingly it is dried in a hot-air chamber, with the precaution of not permitting it to touch the side walls of the sterilizer, which would render the gut brittle. The process of heating should proceed slowly and the temperature never be allowed to exceed 220° F. At 180° the thermometer should be carefully watched to prevent the temperature rising too rapidly, and it should be held at 220° for about thirty minutes. The catgut is next transferred with sterile forceps to an asbestos-lined kettle, where it is allowed to remain in liquid albolene for twenty-four hours. It is then heated on a sand bath in which the temperature is gradually elevated to 320° F. and maintained at this point for one and one-half to two hours. The same precaution is to be employed in regard to the rise of temperature while the gut is in the oil as that employed while it is in hot air, *viz.:* that after the temperature reaches 280° it should be watched very carefully and it is better to keep the temperature at 318°, that is, just short of 320° F., as any rise above 320° would cause catgut to become brittle. The asbestos-lined kettle just spoken of is covered with cardboard, through the centre of which the thermometer is passed. Lastly, the catgut is kept in a sterile condition in glass jars containing one-per-cent crystal iodine in best Columbian spirits. Grain alcohol should not be used. It is well, after the gut has been boiled in oil, to hold it up to allow the excess of oil to drip from it. The sizes used are numbered 1, 2, 3, and 4.

Ordinary catgut, as prepared above, is completely absorbed in from seven to ten days, while it loses its strength several days sooner. For this reason chromicized catgut is valuable, as it is absorbed only in three to six weeks' time. It is readily prepared by first soaking ordinary catgut in ether so as to dissolve out the fat particles, after which it is placed in a four-per-cent aqueous solution of chromic acid, where it remains for twenty-four hours. It can then be sterilized by the Bartlett method. (For further details regarding the sterilization of catgut the reader is referred to Vol. I., p. 728 et seq.)

Silkworm gut is rendered sterile by boiling it with the instruments, or it may be sterilized along with the dressings in the steam sterilizer for one and one-half to two hours. When it is not to be used at once it is kept in grain alcohol, sixty-per-cent strength, to which crystals of iodine have been added in the proportion of 1 : 100.

Horsehair is first prepared by occasional washing in soap and water for five or six days, the water being changed daily. It is then placed in a 1 : 1,000 solution of mercury bichloride for twenty-four hours, after which it is boiled for three minutes. It is preserved in jars containing one per cent crystal iodine in Columbian spirits.

Silk thread and Pagenstecher's celloidin linen thread are both insoluble and remain unabsorbed in the tissues. For this reason their field of usefulness is limited, as they act as foreign bodies and are particularly unsuitable in the region of an infected area. The celloidin thread is generally safer than silk because its smooth surface and firmer texture do not favor the lodgment of bacteria.

Both these materials are sterilized by being boiled with the instruments, but repeated boiling of celloidin thread renders it friable. Silver wire is now but little used. It is sterilized by boiling.

Kangaroo tendon is too expensive to come into very general use. Like catgut it is difficult to sterilize, but has the advantage over catgut in being stronger and less liable to come untied.*

SPONGES AND PADS.

Sponges are of two kinds, the so-called gauze sponges and the natural sea sponges. Sponges made of folded surgeon's gauze have practically replaced the natural variety in most operative clinics. The gauze is cut into pieces of suitable size, and these are then folded into a convenient shape and in such a manner that the loose frayed edges are infolded. All loose threads should be removed. These sponges are placed in cotton bags and are sterilized in the steam sterilizer.

Sea sponges have a greater absorbing power and are more elastic and yielding

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*Dr. Henry O. Marcy, of Boston, Mass., thus describes an effective method of sterilizing kangaroo tendon: "The tendons are taken from recently killed animals, are quickly sun dried, and kept dry till ready for preparation. They are then soaked until soft in a sublimate solution (1: 1,000), carefully separated, sorted, and quickly dried. They are then immersed in ether for twenty-four hours, although this is hardly necessary, as they seem absolutely free of fat. After this they are chromicized and permanently put up in a solution of carbolic oil (1: 10), after the Lister formula for the preparation of catgut. They should be kept in the carbolized oil until required for use, then wrapped in a towel wrung from 1: 1,000 mercuric solution for a few minutes, which makes them supple and easy of application. They do not soften and swell as catgut similarly treated. It must, however, be remembered that every precaution of modern surgery is demanded in placing *aseptic* buried sutures *aseptically* in *aseptic* wounds." (Transactions of the American Association of Obstetricians and Gynæcologists, vol. iv., 1891, p. 186.)

than gauze sponges. It is for these reasons that some operators still make use of them. Their preparation is as follows: Sponges are selected that are about four or five inches in diameter. These are placed for twelve to twenty-four hours in a solution of hydrochloric acid, 1 : 60, in order to dissolve out the particles of lime which they contain. Following this they are thoroughly washed in running water and then placed for fifteen minutes in a saturated solution of potassium permanganate. The nurse then puts on sterile rubber gloves, squeezes each sponge, and places it in a warm saturated solution of oxalic acid until thoroughly bleached. They are then washed free of the acid in sterile water and placed in large glass jars containing 1 : 30 carbolic-acid solution. Just prior to operation several sponges are lifted out with sterile forceps and transferred to a dish of sterile water or salt solution, in which they are thoroughly rinsed and squeezed and are then put in a second basin of salt solution. They can then be cut into smaller sizes if desired and fastened on to sponge-holders and trimmed to a suitable shape. Sponge sticks so arranged are especially useful in sponging deep in the pelvis, etc.

The gauze pad, or Mikulicz pad, consists of several layers of gauze folded into a rectangular shape and sewed so as to present no frayed edges. They may be made in various sizes and should always have a piece of tape sewed on to one corner. The number of pads used at each operation should be known in every instance, so that before the abdomen is closed they can be counted and checked to make certain that no pads are left within the cavity. The long tapes are a further safeguard in this direction as they are left outside the wound and can be temporarily clamped by an artery forceps to the towels. The larger-sized Mikulicz pads are especially useful in packing off the intestines or other viscera, and they should be wrung out in warm salt solution before being placed in position. The smaller sizes are used as sponges. The pads are most conveniently placed in bundles of five or ten, wrapped in cotton cloth, and sterilized in the steam sterilizer along with the dressings for one and one-half to two hours.

An abundance of towels should be always on hand, as they are used for a variety of purposes. They are made into packages of five to ten, covered with cotton cloth, and sterilized in the steam sterilizer. Larger and smaller sheets of cotton cloth are used as coverings for the patient, the tops of tables, etc. The sterile sheet that is laid over the patient in cœliotomy cases is about six feet square and has an opening, or window, about five by ten inches so placed as to lie over the field of operation when the sheet is adjusted.

Drainage Material.

Gauze and other fabric structures, either plain or medicated, are common materials for drainage and are supplemented by rubber tissue, rubber tubes, and glass tubes. In regard to the abdominal cavity it has been clearly demonstrated that drainage is not as necessary a feature as has formerly been thought. If drainage is deemed expedient the best results are obtained by the use of the split spiral rubber tube, or else the so-called cigarette drain with textile fabric unexposed to peritoneal contact.

The successful placing of a gauze drain is an art that requires careful consideration in each individual case. The very object for which the gauze is inserted may be defeated if it is thoughtlessly crammed into a gaping wound, and the ease with which the drainage material may subsequently be removed is usually in direct proportion to the care with which it is inserted. The first care in selecting a gauze drain is to see that all the frayed edges are infolded or else selvedged so that small threads will not break off and be left in the abdominal cavity as foreign bodies. Then, if a single strip of gauze is to be used, one end is placed at the bottom of the wound, and the rest is loosely packed by running it back and forth in successive plaits. In no instance should pressure be allowed on the surface of the bowel or other viscera. In other instances several strips of gauze may be introduced which run in a parallel direction down to the bottom of the part to be drained.

It is generally recognized that there are many better ways of securing drainage than that afforded by the use of gauze alone. The chief advantage that accrues, in certain cases, from gauze drainage is in the adhesions that are formed about the gauze. It is the formation of these adhesions that has led many surgeons to condemn the employment of gauze, but it should be remembered that there is a class of cases in which a successful result depends upon the shutting off of an area by adhesions. It is in just these cases that gauze drainage is indicated and should be used. Associated with this proper employment of gauze should be understood the relation that is set up between the gauze and the tissues, which has a practical bearing on the time of removal of the drain. In the first twenty-four hours an abundance of lymph is thrown out around the gauze; this quickly organizes and becomes invaded by newly formed blood-vessels. If the gauze is removed during this process it breaks up these small vessels and so interferes with the organization of the tissue. As the process occupies about six or seven days, the gauze, inserted for the express purpose of inducing adhesions, should not be removed until this length of time has expired. On the third or fourth day, however, the gauze may be "started" and the central portions of gauze may be removed in those cases in which several strips have been introduced. This manœuvre relieves pressure and accustoms the drainage tract to a gradual closing process. On the seventh or eighth day adhesions are firm enough to allow of the total withdrawal of the gauze, which is now found to have loosened up considerably as compared with its rather firm union with the tissues during the first few days.

The cigarette drain is one of the most satisfactory forms in which to provide temporary communication between the bottom of a cavity and the exterior.

It is easily made by rolling a strip of gauze in a covering, or wrapper, consisting of a thin sheet of rubber protective tissue that is about six inches square. The gauze should not project from the lower end except for special purposes, and then not more than one inch, and this end should be free from frayed edges. After this drain is inserted, the upper end is cut off about a quarter of an inch above the surface of the skin.

There is one serious drawback to all forms of gauze drainage, and that is due to the fact that the meshes in the gauze soon become clogged up with lymph or fibrin and then it ceases to drain. For this reason, where much fluid discharge is to be carried off, it is preferred to use tube drainage. For this purpose one uses either a piece of soft-rubber tubing or a specially shaped glass tube. These tubes are usually open at the lower end and in addition have a number of small perforations along the sides. A sterile wick is usually passed down within the tube, and this can be pulled out when required, and a fresh one put in.

In many respects, for pure drainage, the perforated glass tube is the best because its smooth hard surface does not invite adhesions. The tube should be of such a length that it does not project for more than a quarter of an inch above the surface of the abdomen. If it is longer than this the pressure exerted by the dressings and binder might cause it to press upon the bowel, producing necrosis and a resulting fæcal fistula. It is generally advisable to replace the glass tube, after the first twenty-four hours, with a smaller soft-rubber tube. This can easily be inserted inside of the glass tube, and then the latter pulled out.

It is not purposed here to discuss the indications for drainage nor the technique of drainage in different operative procedures. The employment of stab drainage, vaginal puncture, etc., is fully dealt with in other appropriate chapters. The exposed ends of all kinds of drainage tubes should be covered with a goodly amount of sterile gauze or cotton to quickly absorb all discharges that are brought to the surface. It is almost needless to mention that all drainage material, dressings, etc., that come into contact with the wound should be thoroughly aseptic, and that all subsequent manipulation and dressing of the parts should be done with sterile instruments.

Gauze for drainage use may be medicated in various ways. The chief substances, however, that are incorporated in gauze are iodoform and bismuth. "Iodoform," to quote from Hare, "occupies a unique place among antiseptics in having been almost universally accepted and used by surgeons in spite of the fact that its germicidal action has been proved by laboratory research to be practically *nil*. Furthermore, it has been shown that iodoform is not even sterile, and that, as employed by surgeons, it is frequently a cause of infecting previously aseptic wounds; furthermore, it is poisonous." But the same writer then shows that the drug acts as a powerful disinfectant, not by destroying germs, but by undergoing a decomposition in their presence, the products of which render the ptomaïns, the result of germ growth, inert. "It will be readily understood from the foregoing that iodoform is of little service in aseptic wounds; that it becomes of utility in direct proportion to the foulness of discharge; and that to exert its influence it must be applied directly to the part."

Iodoform gauze may be prepared in two ways. In small amounts it is readily made by rubbing powdered iodoform into gauze that has been moistened with water or a weak solution of bichloride. It is generally prepared for hospital use as follows: one part of pulverized iodoform is thoroughly mixed with four parts of glycerin and eight parts of alcohol. The gauze is now moistened in a weak solution of mercury bichloride and the iodoform paste thoroughly rubbed into its meshes.

Bismuth gauze is preferred by some operators because of the not infrequent susceptibility of some individuals to iodoform. It can be prepared in much the same way as outlined above, by substituting the subnitrate or subiodide of bismuth for the iodoform.

Iodoform and bismuth gauze, as prepared above, may be sterilized by steam.

Dressings.

The essential features of a good dressing are: (1) It should be of sufficient extent thoroughly to cover the wound and its contiguous territory; (2) it should be firmly and neatly applied; (3) it should not exert undue pressure on bony prominences nor be tight enough to interfere with the circulation of the part; (4) it should serve to put the part at rest, while having due regard for the comfort of the patient; (5) in open wounds it should be applied in a sterile condition and so protected as to prevent contamination from the outside; (6) in drainage cases it should be of an absorbent material and of sufficient abundance to care for the amount of discharge that may escape from the wound.

It is not purposed here to discuss the different forms of dressing that are suitable for various operative procedures. The chief material used in dressings is surgeon's gauze, or cheesecloth, supplemented by absorbent cotton. There may be incorporated into dressings for special purposes such substances as starch, plaster of Paris, etc. Furthermore, dressings may be medicated with various germicides and disinfectants and the dressing may be applied dry or wet. Other substances used for dressings are silver foil, collodion containing one grain of mercury bichloride to the ounce, etc.

As a general thing the simpler dressings suffice. In clean cœliotomy cases, for instance, the operative site may be covered with several layers of dry sterile gauze, and over this is pinned a binder. It is advisable so to fasten the dressings that the wound may be uncovered without disturbing the patient. Binders, being made in one piece, do not well conform to the shape of the body, and for this reason it is better to use a Scultetus bandage made of strips of canton flannel. Another simple way to hold dressings in place is to have on hand strips of adhesive plaster one inch and one-half wide and about ten inches long, to one end of which a piece of tape has been sewed. Two or three pairs of these are fastened to the patient's flanks, so that the tapes meet across the median line, where they can be tied.

The wet bichloride dressing is widely used and simply consists of gauze moistened with a solution of bichloride of a strength of 1 : 1,000 or 1 : 2,000. A strip of this kind can be laid over the rows of sutures and then covered with sterile dry gauze.

THE OPERATING-ROOM.

The time is passing when any but trivial operations will be done outside of hospitals. There is abundant reason why this should be so, because of the added safety to the patient as well as the greater convenience and expediency and the great saving of labor engendered by the systematic adjustment of the operating-room machinery. In certain cases, however, in which the patient cannot be moved, it will always be necessary to operate in the home under conditions not the most favorable for brilliant results. Nevertheless, a simple but rigid technique, combined with a certain amount of resourcefulness, should, in many instances, afford the patient the advantages to be had in the hospital.

The hospital operating-room may be a square or rectangular apartment with moderately high ceiling. The walls should be perfectly bare, without mouldings or cornices, while all corners should be rounded off to prevent lodgment of dust particles. In cities it is always preferred to have this room on the top floor of the hospital building, at which height the atmosphere is freer from dust than at the street level. An abundance of light should be secured by a skylight or by large windows, and it is much preferred that the room have a northern exposure. The walls and ceiling should have a hard waterproof finish, so that they can be wiped down with wet cloths. The floor is made of cement, or is tiled, so that an abundance of water may be used daily in washing off the floor. It is very inadvisable to have a drain pipe, or trap, in the floor, as is not infrequently seen in operating-rooms, because such a contrivance is hard to keep clean and may harbor the most virulent organisms.

The proper ventilation requires particular consideration. The windows serve merely for furnishing the needed amount of light, and under no circumstances should be opened prior to or during an operation. While the technical details of ventilation cannot be touched upon here, the chief considerations are to secure a necessary supply of clean air and to provide the necessary exits or outlets. Under no circumstance should the system of ventilation give rise to currents of air in the area occupied by the operating-table because of the danger of chilling the patient while adding to the possibility of infection. As will be readily understood, steam or hot-water heating is much preferred over hot air.

Artificial light is best furnished by an inverted glass dome-like projection in the ceiling which contains electric or gas fixtures, as such a contrivance is much better than chandeliers and brackets.

Only the minimum amount of necessary furniture should be found in the operating-room, and this should be of the simplest construction. Instrument closets, shelves, stationary wash basins, sterilizers, etc., should be in an adjoining apartment. The necessary equipment consists of the operating-table, a table for instruments and one for pads, sponges, and dressings, a few stools, and a receptacle for soiled articles. These pieces of furniture are best constructed of enameled metal ware and heavy plate glass, should be light but strong in construction, and should be free from angles and crevices which will prevent thorough cleaning.

Immediately adjoining the operating-room, or in very close proximity to it, are the rooms for administering the anæsthetic, the surgeons' dressing-room with the basins and solutions for hand disinfection, and the sterilizing-room with its necessary appurtenances.

Operating at the patient's home may be necessary, and it is always well for the surgeon to be fully prepared for any emergency that may arise. As a rule this applies more to those men who are engaged as railway surgeons, and the many details connected with this class of emergency surgery will be fully dealt with in another chapter. (See Vol. VIII.) But the man located in sparsely settled districts, away from hospital centres, is often called to do serious major operations, and with the more limited facilities come even added responsibilities.

If it is decided to operate in a private dwelling, and the case is not an urgent one, a room should be selected for the purpose, all furniture removed, the carpets taken up, and all hangings removed from the walls and windows. The walls should be wiped down with a damp cloth and the floor then thoroughly cleaned with hot water and soap. In the event of an emergency case, however, as little disturbance as possible properly to meet the demands should be made because it only serves to stir up the dust. Hangings should be left untouched. Clean sheets carefully fastened to the walls, especially those nearest to the patient, are advisable. The floor should be well sprinkled with plain water or a solution of mercury bichloride or carbolic acid.

It is most advisable that the operator bring his suture and drainage material, sponges, towels, and dressings, already sterilized, so that it will simply be necessary to boil the instruments at the patient's home. A quantity of boiled and cooled water should be on hand, and this is most conveniently contained in a large wash boiler. Several china basins and pitchers should be sterilized by boiling or with carbolic acid 1 : 20, and then covered with sterile towels. In place of instrument trays one can use plates and platters, or enameled or agateware dishes, etc., may be at hand or can be bought at a shop.

An improvised operating-table can be variously made, unless the surgeon carries with him some form of portable table, several kinds of which are on the market. A kitchen table is most generally brought into use, and on this may be placed a narrow wardrobe door or a window shutter. The Trendelenburg posture can be arranged for by tipping up a small straight-back chair on the table and leaning the improvised board on this.

Operations outside the hospital can be comfortably conducted with the aid of the surgical outfit trunk as used by Dr. J. M. T. Finney, of Baltimore. This trunk is about the size of a small steamer trunk and is kept packed with all the necessary supplies for an operation except the instruments, and these can be quickly put in. The chief novelty about this trunk, however, is that it opens

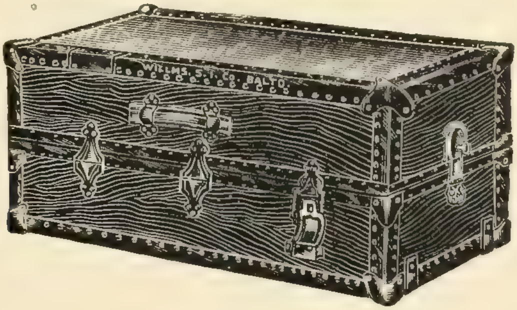
WILLMS S.T. CO. BALTO.

FIG. 64.—Finney-Pancoast Trunk, Closed.

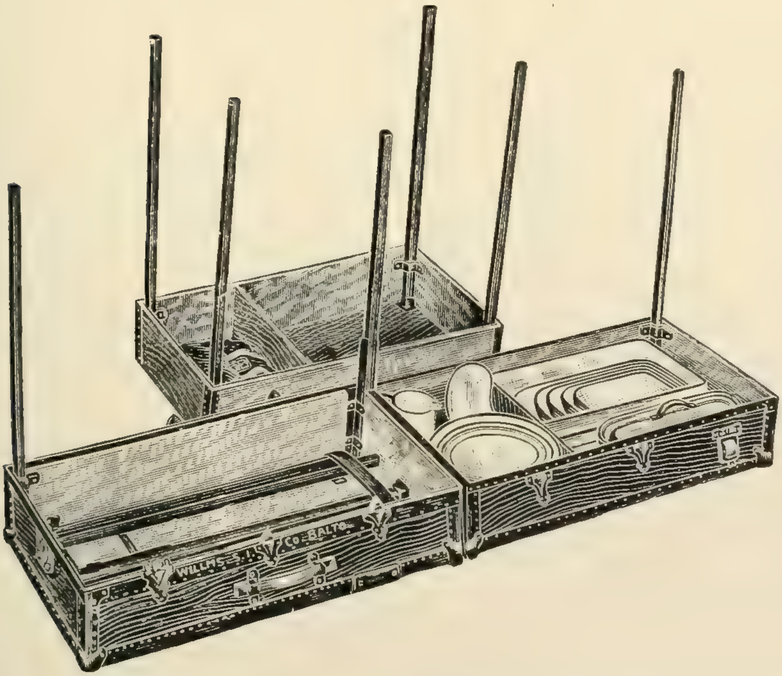
WILLMS S.T. CO. BALTO.

FIG. 65.—Finney-Pancoast Trunk Opened, and Tray Removed and Placed on One Side. The surgeon's instruments and the various porcelain-lined basins and receptacles are shown as they are packed in one of the halves of the trunk. The legs which are to be used in converting the tray and the two halves of the trunk into separate tables (the two halves of the trunk forming an operating-table), are packed in the other half. In the illustration most of these legs have been unpacked and placed in their respective sockets.

endwise and is so jointed and arranged that after being emptied it is propped up on legs and serves as the operating-table. It can be easily carried on a cab to the railroad depot, checked, and go with the surgeon on the same train.

Dr. Finney and Dr. Omar Pancoast describe their method of using this outfit in the following terms:

> The large arm basin containing four or five instrument trays is immediately filled with a 1 : 1,000 solution of bichloride of mercury and the trays are thus sterilized by soaking. When taken out each may be covered with a sterile towel or tray cover. The largest of the round basins is filled with bichloride solution, and the smallest of this set is sterilized by shaking in the same manner. The large basin is finally used for the operator's hand-basin of bichloride, and the small one for sterile water, salt solution, or sponges as the occasion requires. Two of the round basins are used for the saturated solutions of permanganate of potash and oxalic acid. The remaining one is for the soap and water used in shaving and cleaning the site of operation. The instruments are carried packed in the kettle and so may be boiled at once.

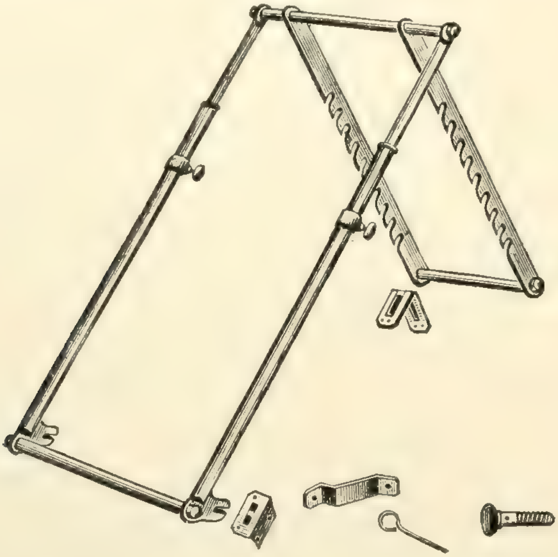

FIG. 66.—Portable Trendelenburg Fixtures, with the Separate Clamps, Screws, and Pins Needed for Fastening it Securely to the Operating-Table. The whole can readily be packed, together with the removable table legs, in one of the halves of the trunk.

In order to form a rigid table the trunk when open is securely fastened in this position by a thumb screw. The legs after insertion may be clasped very tightly by a few turns of the screw which regulates the size of the opening in the corner castings. The table is usually covered with a folded blanket, mackintosh, sheet, and a Kelly or Morrison pad which drains into a bucket on the floor. When the Trendelenburg is used the trunk is protected by a mackintosh alone, while a pillow is placed over the cross rod of the Trendelenburg to protect the patient's head and shoulders. The various chemicals necessary are carried in ordinary mailing cases so as to avoid the danger of breakage when glass bottles are carried. We use the wooden cases with screw top after carefully washing them and removing the wadding and paraffin. Sterile concentrated salt solution, cocaine, etc., are carried in bottles in mailing cases and are previously sterilized by the following process: A cork is put lightly in the bottle containing the solution, and the whole top of the bottle and cork are then covered with an absorbent-cotton shield fastened around the neck of the bottle. After sterilization the cork is pushed home through the cotton, and the solution remains sterile indefinitely.

Various large-sized handbags can be kept on hand by the surgeon, and in these are packed the instruments together with sterilized and labelled packages of sponges, towels, gowns, etc. The following list may serve as a guide in packing such a case:

Sterilized.

Towels, 2 packages of five each.
Gauze, 3 to 4 packages.
Operating gowns.
Tablets of sodium chloride.
Safety pins.
Sponges, 2 bags of twenty-five each.
Absorbent cotton.
Nail brushes.
Infusion apparatus.

Unsterilized.

Razor.
Tablets of mercury bichloride.
Ether, or chloroform, and mask.
Rubber gloves.
Binder and bandages.
Green soap.
Alcohol.
Rubber pad.
Hypodermic syringe and drugs.
Rubber sheet.
Instruments.

The Operation.

Choice of Anæsthetic.—General anæsthesia may be produced by ether, chloroform, or nitrous-oxide gas. The introduction of the drop method has rendered the use of ether most satisfactory, and its far greater safety should command its general use. The only instances in which chloroform can be better substituted for ether are in acute bronchitis, and in operations about the face or mouth in which the actual cautery is to be used, or at night in the vicinity of the gas flame. Nitrous-oxide gas is of special service in minor operations and, if it is thought desirable, as a preliminary to ether. With the services of a skilled anæsthetist, however, this gas can be used in operations lasting ten or twelve minutes, although complete relaxation is difficult to secure.

Local anæsthesia by means of cocaine has a rather limited field of usefulness, except in palliative operations on desperately ill patients, in the removal of goitres, and in minor surgery.

The induction of anæsthesia by means of intradural injection of cocaine or stovain, and by the hypodermic administration of scopolamine and morphine, has not been widely accepted, and the method, except, possibly, in certain selected cases, offers no ground for adoption over the usual plan of administering ether.

The Care and Comfort of the Patient.—The anæsthetized individual, while insensible to pain, is susceptible to injury—a fact that is too often lost sight of. The patient should be lifted and placed upon the table with all gentleness, and should then be placed in as comfortable a position as is compatible with the nature of the operation. Special emphasis must be laid on one point, and that is to support the patient's back when he is laid supine on a hard table. It seems extraordinary that so little attention is directed to this feature, when the surgeon in his rounds day after day finds the strongest men, when first confined to bed, completely unnerved by a constant agonizing pain across the small of the back, while the clean-cut abdominal wound, with its severed nerve twigs, is not even mentioned. It should be remembered that general anæsthesia causes complete relaxation of all the voluntary muscles, and that if the dorso-lumbar curve in the spinal column is not supported the dead weight of the corresponding part of the body falls upon the spinal ligaments, and a severe strain, if not a true sprain, results. This occurrence can be entirely obviated by placing a pillow, or inflated cushion, under this part of the back, but the writer finds the most satisfactory contrivance is a bag containing unground flaxseed. The smooth seeds readily slip upon one another and so arrange themselves as to conform to the part that receives the pressure.

Great care should be taken, as to the disposition of the arms and legs, that they do not fall over the edge of the table and so induce a pressure paralysis. Furthermore, the anæsthetist should realize that continuous or strenuous efforts in holding the jaw forward may seriously affect the patient's comfort for several days after the operation because of tenderness or lameness thus caused. Another point that the operator should have in mind is to see that the assistants do not lean upon the patient's chest or legs. While it seems almost superfluous to mention this possibility, yet it is surprising how often a thoughtless assistant will rest his elbow or arms upon the insensible body as if it were a part of the table.

It is most important to see that the patient is warmly clad, because of the increased heat radiation during the period of anæsthesia and unconsciousness. Before the patient is etherized the nightgown should be removed and a thick canton flannel jacket put on. This should fasten down the back, have long sleeves and a short waist. The legs and feet should be encased in long leggins made of canton flannel or of pieces of old blankets.

At no time should any portion of the body be unnecessarily exposed, and, what is most important, the patient's body must be kept dry. In cleaning up the field of operation a most pernicious practice consists in sousing the patient with quantities of sterile water or bichloride solution, with the result that he lies in a pool of water during the entire operation. Operative technique has now been perfected to such an extent that these seemingly small details may well be looked into, as they constitute a definite factor in post-operative mortality.

The Incision.—The cutting of tissues must have regard for the structures severed and their subsequent power of repair. This applies particularly to muscles, nerves, and blood-vessels, and entails the knowledge of function as well as of morphology. The needless cutting of parts should not be engendered as a habit, but on the other hand the incision should be sufficiently ample to allow for the expeditious examination and repair or removal of diseased tissues. If one attempts to operate through an incision that is too small, valuable time and tissue vitality are often sacrificed. Furthermore, a long clean incision will heal more quickly than a short one the edges of which have been pried apart with retractors and otherwise bruised and mishandled.

Hæmostasis.—The careful controlling of all bleeding points is very essential for two reasons: (1) to conserve every possible particle of blood in the patient's body; and (2) to keep clear the field of operation.

The first point needs no arguments, but, as regards the second, the time occupied in tying off the smaller vessels is more than made up by the increased facilities afforded by working in a dry area. Small bleeding points may be easily occluded by a temporary clamp or the pressure of an artery forceps, while the larger vessels can be picked up with forceps and ligatured with fine catgut. If the actual bleeding point cannot be secured a mass ligature may be passed deep into the tissues of the part, but great care should be taken so as not to include the larger nerves, or ducts, such as the ureter, etc. A moderate degree of general oozing can be controlled by temporary pressure applied with a gauze pad, or by gauze that has been wrung out of very hot water, while in other instances it may be necessary to sear the surface with the actual cautery. In operating upon easily accessible parts as in the nose and throat, where the dangers of secondary hemorrhage are not great, a nearly bloodless field can be secured by the application of adrenalin chloride in salt solution in strengths of from 1 : 1,000 to 1 : 10,000, supplemented if advisable by cocaine.

The temporary occlusion of the larger vessels, as in operations upon extremities, is best secured by the pressure of a tourniquet. The limb should first be well elevated, or else bandaged, so as to drive out as much of the contained blood as possible, then the pressure is made at a point well above the operative site. Care should be enjoined in the application of a tourniquet, as the amount of pressure necessary is that which is just sufficient to obliterate the pulse in a distal artery. A strong-armed assistant may seriously affect the more delicate structures of a part and the nerve trunks by the needless tightening of the elastic band, and for this reason, too, it is well first to wrap a towel about the limb and then apply the tourniquet over this. If the operation is to be done very near the junction of the limb with the body, as in amputation at the hip joint, the elastic bandage may be prevented from slipping off by first passing through the soft tissues two Wyeth's pins or skewers and applying the constricting bandage above these.

The survey, or careful examination of the operative area, should be made as soon as the abdomen is opened. This should not be confined to one suspected area, but should include, if requisite and feasible, a general survey of the whole cavity. This examination, however, should be done as rapidly as possible and with the greatest care and gentleness, because it is quite impossible to prevent bruising the delicate mesothelial layer of the peritoneal coverings of the viscera. Needless handling of the tissues cannot be too strongly condemned, but the success of the operative procedure may depend upon finding a primary focus of the disease, or an accessory condition.

The isolation of the operative field is of the utmost importance in all cases where a septic focus is to be incised or extirpated, while in every case it facilitates and expedites the manipulative procedures. This packing off is best accomplished by the use of large Mikulicz pads. These should first be wrung out in warm sterile salt solution. These gauze pads may be simply used to push back the coils of intestine, or may surround the operative area on all sides as a barrier.

Operative work in the pelvis is much facilitated by placing the patient in the Trendelenburg posture by which the intestines are made to gravitate toward the diaphragm. This posture may be capable of causing harm, however, in operating upon infected areas in the pelvis, because some of the contaminated fluid may escape upward among the coils of intestines. As the peritoneum of the lower abdominal zone has been proved to have a lesser absorptive power than that in the upper zone, every effort should be made to favor drainage downward and to keep the infection strictly localized. In operating upon elderly individuals with weakened arterial walls the Trendelenburg posture may be a factor in inducing a cerebral hemorrhage. Such an accident may explain a rare group of cases in which, under these circumstances, the patient never rallies from the anæsthetic.

In operations on the breast and shoulders the close proximity of the patient's head, anæsthetizing apparatus, etc., increases the danger of contamination of the field. This can be obviated by fastening a barrel-hoop or a specially bent metal rod, with either end on each side of the table, at a level with the patient's neck. Over this is draped a sterile sheet so as to form a complete barrier between the anæsthetist and the head and the rest of the body of the patient.

The arrangement of the instrument tables and those for the dressings, etc., may vary to suit the convenience of the operator. These tables should be covered with sterile sheets, and the instruments arranged in shallow sterile pans or trays, or spread upon sterile towels. If it is preferred to keep any of the instruments in a carbolic-acid solution they must be rinsed off in sterile water or salt solution before coming in contact with delicate tissues.

Post-Operative Treatment.

The most brilliant achievement at the operating-table may pass for naught because of ignorance or oversight on the part of those to whom the busy surgeon is too often compelled to entrust the post-operative treatment. While much has been learned concerning the successful handling of patients in the first few days following operation, yet a great many facts have had to be unlearned, and this applies particularly to the routine administration of cathartics and stimulants. The comfort, as well as the safety, of the patient is very much modified by the manner in which the post-operative treatment is applied. In addition, during the period immediately following operation unlooked-for complications may arise that may seriously modify or even jeopardize an otherwise favorable course, and in such instances it is the very prompt recognition of post-operative conditions that often saves life. Post-operative treatment, then, may be divided into: (1) The treatment of uncomplicated cases; and (2) the treatment of various complications and sequelæ that may occur.

The patient, immediately after operation, should be carried to a quiet, darkened room and placed in bed. Before the patient leaves the operating-room the ether-jacket, leggins, etc., should be removed and the body thoroughly dried. A clean gown is now put on and the whole body well covered with blankets. If every care is taken to see that the body is well dried and well protected it is found that two of the most serious post-operative complications—shock and pneumonia—are far less commonly encountered. It should be thoroughly impressed on the surgical staff that the most common cause of these two serious conditions is the failure properly to protect the patient during the passage from the operating-room to the ward *via* corridors, elevators, etc., while the patient is damp with sweat and only half clothed.

After the patient is placed in the bed he should be covered with warm blankets and hot-water bottles applied, or the bed may have been well warmed by the hot bottles just removed. If the bottles are applied they should first be well protected with flannel covers, as the insensible body may be very easily burned by contact, and such complication may confine the patient to bed for a much longer time than that required for thorough healing of the operation wound. A responsible nurse should remain constantly in attendance until consciousness is fully restored, for the purpose of preventing any accidents in the semiconscious period.

It is very desirable to relieve as expeditiously as possible the nausea and vomiting that may occur. To this end the practice obtains in some clinics of trying to keep the stomach at rest by withholding everything by mouth and exhibiting very small doses of morphine. Such a practice, however, has a tendency to retard elimination in general and rather serves to protract the period of nausea. In any large series of cases it can be readily demonstrated that a far better practice consists in the free administration of hot water which is given by mouth in sips or perhaps in such amounts as the patient may desire. This course often induces one or two spells of vomiting, but at the same time the stomach is being washed out and the nausea subsides very quickly as a rule. An exception to this practice should be taken in operative work on the stomach and in cases of peritonitis, as everything must be done in these instances to quiet peristalsis. The water by mouth is further supplemented by small quantities of salt solution, 200 to 300 c.c., per rectum every four hours. The free administration of water not only hastens the elimination of the ether, but also supplies fluid for active kidney work and militates against the occurrence of shock.

Nourishment of all forms may be withheld for thirty-six to forty-eight hours until the digestive organs have regained their tone. At this time it is well to start with fresh milk and lime water, butter-milk, or perhaps lager beer, each of which is particularly well borne as a rule, but albumin water flavored with fruit juice or sherry, or tea and coffee, may be more acceptable. This list of liquid foods may be quickly extended and the patient will begin to eat solid food on the fifth to the seventh day according to his progress and the nature of the operation.

Meddlesome after-treatment cannot be too strongly condemned, and this is characterized by the routine administration of cathartics, stimulants, and various pain-killers and sleeping potions. These points should be carefully followed by the operator, for there is an enormous capability of harm in the over-energetic house doctor who has a symptomatic remedy for every condition.

Early purgation after abdominal operations is in most cases not only unnecessary but also decidedly pernicious for the following reasons: in the first place the alimentary tract has been thoroughly cleaned prior to operation, while the patient is not at this period ingesting food. What is far more important, however, is the fact that purgative drugs at this period may serve to produce an artificial condition simulating an acute obstruction. This is explained by the fact that the handling of the intestines, it matters not how gently, is apt to induce adynamic paralysis coming on about six hours after operation and lasting for from thirty to forty hours. Now if purgative drugs are administered peristalsis is set up in the proximal portion of the gut which is at once blocked in the paralyzed area. The result is abdominal distention associated with cramp-like pains, nausea, and vomiting. No possible harm can be apprehended simply because the bowels do not promptly move after operation, except, of course, in the event of a real obstruction, and this complication demands radical treatment and not palliative attempts with cathartics.

Routine stimulation with drugs is a practice mentioned only to be condemned. Cases will arise, of course, in which appropriate stimulation is absolutely essential, but these require most deliberate consideration lest such a condition as surgical shock, which in itself is an overstimulation, be seriously aggravated. In urinary suppression, too, of what avail is the unbalanced attempt at securing diuresis by the exhibition of sparteine, when the most efficient of all diuretics—water—is being withheld? How frequently is caffeine administered three or four times during the day, after which the doctor is surprised at the sleepless night that follows? When a stimulant is really needed the most reliance can be placed in physiological salt solution given by rectum, under the skin, or intravenously. The use of this valuable agent has marked an era in things surgical that with proper utilization ranks high in the scale of therapeutic attainment. The indiscriminate employment of salt water, however, may be provocative of harm. Such is the case in pneumonia, congestion of the lungs, and whenever there is indication that the right side of the heart is embarrassed. This danger is more marked in introducing salt solution directly into a vein, because when given by bowel or under the skin Nature is granted the privilege of indicating when she has had enough and refusing to take more, whereas by the transfusion method an overworked heart may be quickly impaired by the abnormal increase in the volume of the blood. The intravenous infusion is of especial value in cases of acute shock and of marked hemorrhage and in conditions associated with low pulse tension.

COMPLICATIONS.

Excessive Vomiting.—In occasional instances nausea and vomiting following the anæsthetic do not promptly cease, but become so aggravated as seriously to jeopardize the patient's welfare. In this regard it is interesting to note that ether causes nausea and vomiting more frequently than chloroform, but more cases of protracted and dangerous vomiting are met with after chloroform than after ether. In most cases excessive vomiting seems to depend upon a special idiosyncrasy.

The treatment may present decided difficulties. Proper preparatory treatment may act as a prophylactic against vomiting in general, but these severe cases occur in spite of it. The most valuable procedure is repeated lavage of the stomach with hot water, the stomach tube being used for this purpose if necessary. Sodium bromide in large doses by rectum may act very beneficially. If it is possible to retain anything on the stomach for a period, a very useful remedy is a tablet containing gr. ii. each of cerium oxalate and bismuth subnitrate with $\frac{1}{12}$ of a grain of cocaine. If these measures fail it will be necessary to resort to morphine hypodermically.

Post-Operative Hæmatemesis.—This is a rather infrequent complication which may follow upon any operative procedure in the abdomen, although it is more commonly noted after manipulation of the stomach, duodenum, or bile passages. The hæmatemesis begins as a rule within twenty-four hours after operation, but may not occur for several days. The condition is characterized by the frequent vomiting of small amounts of altered blood and is usually independent of the nausea and vomiting due to the anæsthetic. The blood shows evidence of having been acted upon by the stomach juices and has the characteristic "coffee-ground" appearance. The vomitus is very acrid in nature and may burn the patient's lips and chin. An initial period of alertness and anxiety soon gives way to apathy and it is readily seen that the patient is very much depressed. The temperature is often subnormal, the pulse small and weak and of increased frequency, the skin is moist with a dusky appearance, and, if the condition is not quickly relieved, pronounced symptoms of collapse quickly supervene.

The ætiology of post-operative hæmatemesis is not definitely known. The pronounced general symptoms are not easy to explain by the various hypotheses that have been adduced. The writer believes with von Eiselberg that injury to the omentum with thrombosis of its vessels may lead to infarction of the vessels in the walls of the stomach, but that this does not explain all. It is therefore suggested that the symptoms depend more upon an involvement of the sympathetic nerve plexuses and ganglia, secondary to circulatory disturbances resulting from traumatism. In accordance with this view is the opinion of Mayo Robson, who speaks of the condition as being in a general way dependent on "a reflex nervous influence." Sepsis does not appear to be a prominent factor, nor can the anæsthetic be held responsible, as the condition has been observed following operations done under cocaine.

The treatment cannot be rationally formulated in the absence of the known cause of the condition. The patient should be kept absolutely at rest, and this is best secured by small doses of morphine. Adrenalin is probably one of the most useful drugs in this condition and should be given in ten-minim doses of the standard 1 : 1,000 solution of adrenalin chloride by mouth every half-hour. If the patient is not profoundly shocked, much relief may be obtained by gastric lavage, while if collapse is imminent an intravenous infusion of salt solution should be given, and it may be well to add to this a 1 : 1,000 solution of adrenalin chloride in the proportion of two drachms to the pint of salt water.

Acute Gastric Dilatation.—One of the most serious post-operative complications is acute dilatation of the stomach. Fortunately, it is comparatively rarely encountered, but when present demands immediate and energetic treatment. The onset is acute, about twenty-four to forty-eight hours after operation. The most characteristic symptoms are the vomiting of very large amounts of brownish, greenish, or black fluid, and abdominal distention. Associated with these symptoms there are great thirst, subnormal temperature, and a cold and clammy skin, all of which go to make up a picture similar to that of impending collapse in peritonitis. The diagnosis can be made at once with the stomach tube, which seems almost to become lost in the enormously distended viscus, while it allows the escape of much gas and of very large quantities of the characteristic fluid. Furthermore, the abdominal distention is chiefly confined to the upper half of the abdomen and a succussion splash may be easily elicited.

The cause of the condition seems to be a motor paresis of the musculature of the stomach, associated with marked hypersecretion and possibly regurgitation of fluid from the upper intestinal tract, although the vomitus does not become feculent. It is most probable that this depends on a local disturbance of innervation, but it may be an expression of general toxæmia.

The treatment is prompt and repeated washing out of the stomach, which may be supplemented, if deemed advisable, by the administration of strychnine and ergot. It must be emphasized that this is a serious condition and that the life of the patient depends upon its prompt recognition and energetic treatment. The lavage should be continued until the fluid returns clear, and should be repeated every hour or oftener as long as the condition persists. Hot turpentine stupes should be frequently applied and a tight abdominal binder kept in position. A faradic current may be used over the epigastrium, but, if the stomach condition is simply an expression of a general toxæmia, appropriate measures should be employed to secure elimination, etc.

Abdominal Distention.—The formation of an excessive amount of gas in the intestines is a serious menace to the welfare of the patient and may jeopardize the integrity of any suture work that may have been applied to the intestinal tract, while it may cause the parietal incision to break open. If mechanical obstruction of the bowel and acute gastric dilatation be excluded, the two commonest causes of this condition are toxæmia and the unwise employment of early purgation, as fully explained above.

To relieve the state of affairs a rectal tube should be passed for a distance of eighteen inches up into the large bowel,—a procedure which may at once prove effective by allowing the escape of much flatus. In order to prevent kinking of the tube it is well to attach it to a fountain syringe so that the column of fluid may distend the bowel in front of the tube and so facilitate the introduction of the latter. If the rectal tube alone does not suffice an enema containing turpentine, ʒ ii. to iv. to the quart, may be tried, and turpentine should be also applied externally in the form of hot stupes. Magnesium sulphate and glycerin are also valuable adjuncts in the enema. In obstinate cases very striking results are sometimes obtained by the faradic current so applied that one pole is introduced through the tube into the bowel filled with water. The use of eserin salicylate had been advocated in doses of $\frac{1}{80}$ to $\frac{1}{40}$ of a grain given hypodermically. This drug is a direct stimulant to unstriped muscle fibres and theoretically is useful, although its employment in tympanites has not given uniformly satisfactory results, while it may act as a dangerous depressant to the central nervous system.

Intestinal Obstruction, or ileus, occurs only rarely after intra-abdominal operations. It may be divided into two groups: (1) Strangulation ileus, in which, in addition to the obstruction to the lumen of the intestine, there is interference with the mesenteric blood supply; and (2) obturation ileus, in which the blood supply of the obstructed portions of the gut is not disturbed. The first group gives rise to very acute symptoms, as intense pain, primary reflex vomiting, and shock. The later symptoms are distention and secondary vomiting which is faecal in character. In obturation ileus, however, the symptoms may be obscure at first, and it is fortunate that the patient may survive for a longer period from the onset of symptoms to the time of operative relief. Pain at first is general and not very acute, and the diagnosis cannot be made as a rule until visible peristalsis, distention, and vomiting complete the picture. It should be remembered that visible peristalsis occurs only early in the obstruction, and that in a certain proportion of cases it cannot be demonstrated after distention supervenes, because there is usually complete paralysis of the intestine. Examination of the abdomen shows it to be held somewhat rigidly, but there is little, if any, localized tenderness. An enema gives no relief, and if the lower bowel is cleansed out with one enema, a succeeding one comes away clear. A valuable sign in early obstruction, and one upon which Bloodgood lays emphasis, is a high leucocyte count, from 20,000 to 35,000.

The treatment is eminently surgical, although in rare cases it may be possible to obtain results from gentle massage, from distention of the large intestine with water when the obstruction is located in that portion of the gut, or by the administration of large doses of atropine to relax spasm of the intestinal walls. Guarded attempts at catharsis are recommended by some writers, but they generally serve to aggravate the condition. If the diagnosis, however, has not been made very early, any conservative line of treatment should be absolutely disregarded and the abdomen at once opened. Morphine should not be given for pain unless operation has been decided upon.

Peritonitis.—Through modern aseptic measures and skilful surgery this grave complication of abdominal operations has been largely done away with. However, in certain acute cases, where the preparation of the patient's alimentary tract is an impossibility, or where operations upon the alimentary tract are undertaken, peritonitis will sometimes arise in the practice of even the most skilful. Experiments upon animals have been undertaken with the purpose of elaborating a method by which the resistance of the peritoneum might be increased through increasing the phagocytic power of the blood, but up to the present time no satisfactory or practical method has been devised.

After an abdominal operation, if peritonitis sets in, the pain instead of subsiding grows worse; the abdomen becomes distended and tympanitic; vomiting and nausea persist; the pulse gradually increases out of proportion to the temperature. The patient looks anxious and careworn, the skin is cold and clammy, and the approach of collapse is evident. At this time the pulse rate and its relation to the temperature are matters of great diagnostic importance. Should the pulse remain above 120 and the temperature continue to fall, the prognosis is most serious. The patient lies upon his back with legs flexed upon the thighs in order to relax the muscles of the abdomen. The vomited matter at first consists of clear fluid, but later becomes of a dark color and is brought up in great quantities. The tongue is dry and coated and there may be persistent hiccoughing in the intervals between vomiting. These patients may say that they are feeling well, but are very thirsty; or, in some instances, half an hour before death, they may express themselves as feeling "fine" and ask for nourishment.

As to treatment, some authorities advise purgation, but the writer is of the opinion that when the bowels can be made to move freely, it indicates that the infection is mild or localized and recovery could be counted on as surely without purgation as with it. Furthermore, peristalsis simply favors the spread of the infectious material and so may defeat any attempt on the part of nature to wall off the infection. If there is leakage, the abdomen must be opened up, the point of leakage found and repaired, and drainage established. Elevation of the head of the bed, or "Fowler's position," is of prime importance in cases of peritonitis, since it lessens the absorption of toxic material, owing to the fact that the diaphragmatic portion of the cavity possesses much more absorptive power than the pelvic peritoneum. While this simple postural procedure marks one of the greatest advances in the treatment of peritonitis, it should not be relied upon to the exclusion of other methods, but should be employed rather in conjunction with them. Free incision, flushing with abundance of hot salt water, and the insertion of suitable tube drainage are measures of almost equal importance. Drainage should be at the lowest portion of the pelvis as well as at the site of the operative incision. It may be well to make an opening from the cul-de-sac into the vagina. A Murphy's tube should be introduced into the rectum and normal saline allowed to trickle continuously into the gut. All food and liquid by mouth should be stopped, and if some nourishment is imperative it may be introduced with the saline per rectum. The operation for drainage should be rapidly performed and the tube drains be allowed to remain in place according to the judgment of the surgeon, and the removal should be cautious and gradual.

Surgical Shock.—For a complete résumé on the etiology, symptomatology, and treatment of this condition the reader is referred to the article in volume I.

Pneumonia.—Post-operative pneumonia may be either a true lobar pneumonia or a broncho-pneumonia, more frequently the latter. This dreaded complication is certainly of less common occurrence at the present writing than it was ten years ago, although its exact relation to the operative procedure is still obscure. The anæsthetic alone cannot be held responsible as the predisposing agent, for it has been definitely demonstrated that pneumonia occurs in about the same proportion of instances in which the operations have been performed under local anæsthesia. It has been plausibly suggested that the voluntary immobilization of the abdominal muscles after cœliotomy prevents the patient from correctly expanding the chest and hinders the act of coughing, so that if he already has a low-grade infection, as represented by a subacute bronchitis, the retention of infected secretions may excite a spread of the infection from the tubes into the lung tissue proper.

The fact that pneumonia so much more commonly follows operations about the mouth and air passages shows that in many instances it is really an aspiration pneumonia. For this reason in general operations the condition of the mouth may be a factor, and for the same reason a fresh gauze inhaler should be used for each patient.

Attention has already been called to the liability of pneumonia following upon chilling of the patient's body during and after operation. This factor may be the most important of all in the etiology of post-operative pneumonia, and the surgeon will do well to make sure that the younger house men use every precaution in this respect.

The treatment of post-operative pneumonia is the same as that generally employed on the medical side.

Retention of Urine.—The inability of the patient to empty the bladder may be due to several causes. The unaccustomed dorsal position often makes it difficult to void urine, while in other cases the most potent factor seems to be a nervousness. Retention is most commonly observed after operations in the pelvis or about the perineum, and is then associated with traumatism of the parts. It is particularly apt to occur following operations for hemorrhoids and then seems to be reflex in nature. Semiconscious patients, or those profoundly shocked, should be inspected regularly to avoid undue distention of the bladder.

In the treatment of retention simple measures will usually suffice if persisted in. Stupes wrung out in very hot water and applied as hot as can be borne just above the bladder usually cause relaxation. Or one may try a hot perineal or vaginal douche. In especially neurotic individuals excellent results may be obtained by administering a very large enema of hot water if there is no contraindication to such a procedure. The bladder will usually be emptied during the expulsion of the enema. If these measures fail catheterization must be resorted to in order to avoid paralysis and over-distention of the bladder.

It should be understood that the employment of the catheter involves considerable responsibility, and it is essential that the use of this instrument should be confined to the doctor or to nurses who have been thoroughly instructed as to the great importance of maintaining strict asepsis. The catheter should not only be sterile, but the parts must be carefully cleansed. In spite of all precautions in these respects a certain proportion of infections do occur and it is an excellent routine practice always to administer a urinary disinfectant, as urotropin, by mouth in every case in which an instrument is introduced into the bladder or urethra, and this may be supplemented by bladder irrigations of half-saturated boric-acid solution, or a solution of mercury bichloride in the strength of 1:40,000.

Suppression of Urine.—This complication is rarely encountered if a point is made of freely administering water to the patient both before and after operation. Anuria occurs most frequently following operation upon the kidney, after which the other kidney may be reflexly affected. The condition also arises, of course, when there is an anatomical anomaly and the only kidney present is removed. An acute nephritis may develop and be responsible for the condition. In the author's experience suppression of urine is more frequently encountered following the use of chloroform as the anæsthetic than when ether is employed, and such anuria, being associated with an acutely developing fatty degeneration of the kidneys, is thought to be due to the toxic action of the chloroform.

The treatment of suppression of the renal secretions consists in the introduction into the body of large quantities of physiological salt solution by the bowel, tissues, and veins; counterirritation over the kidneys by either dry or wet cups; and promoting excretion by the bowels and skin. The bowels should be made to act promptly and effectively by administering elaterium in doses of $\frac{1}{4}$ to $\frac{1}{2}$ of a grain, or by giving jalap, best in the form of the compound jalap powder, gr. xxx. to gr. lx., which has also a diuretic action due to the combination with potassium bitartrate. The patient should be placed in a hot pack every three hours, or, if the condition will permit, a sweat bath by means of superheated dry air may be given twice a day. All diuretics, with the exception of water, should be guardedly used and the diuretic salts, as potassium citrate or acetate, are safer than the more stimulant diuretics.

Cystitis.—Infection of the bladder together with the genito-urinary apparatus occurs most frequently after operation upon or instrumentation of some part of the tract. The condition is usually called attention to promptly by the patient because of the frequent desire to micturate, associated with burning or tenesmus. But these symptoms may be slight, and whenever an unexplained elevation of temperature occurs during the convalescent period the urine should be at once examined.

Treatment should be instituted promptly. The giving of water by the mouth should be forced, and a urinary disinfectant administered. Bladder irrigations with solutions of permanganate of potash, boric acid, mercury bichloride, or argyrol may be used. The pain and tenesmus may be relieved by a suppository containing opium, codeine, or hyoscyamus, or the following useful formula may be given by the mouth:

℞	Potass. acetatis	℥ i.
	Tinct. hyoscyami	ʒ vi.
	Aquæ	q. s. ad ℥ iij.

M. S. One teaspoonful three or four times a day.

Heart Complications.—The musculature of the heart is always affected in conditions of sepsis and toxæmia. Furthermore, if the heart muscle is already weakened by the presence of fibrous tissue or by an infiltration with a smaller or larger proportion of fat, the shock of the operation with all its irritating afferent impulses may seriously jeopardize what sound muscle tissue still exists. The fact that patients with well-compensated valve lesions usually withstand operations well warrants the assumption that the heart muscle is strong and of good quality. Right here may be mentioned the not infrequent association of myocardial degeneration with fibroid tumors of the uterus, although its significance is not well understood.

Aside from post-operative heart complications that are definitely dependent upon myocardial degeneration, there is a very interesting condition that occasionally arises and that is due to acute cardiac dilatation. A patient who gives every indication of doing well twenty-four to forty-eight hours after operation may suddenly be seized with severe precordial pain and sit up in bed gasping for breath, while the lips become markedly cyanosed. The condition differs from angina pectoris not only in the physical findings but in the fact that there is no feeling of constriction about the heart, but rather a sensation as if the heart would burst. Hasty examination will show a tumultuous heart action and a greatly increased area of cardiac dulness. The condition is seemingly obscure in its causation, as no lesion is found post mortem.

Closely allied with acute cardiac dilatation is acute pulmonary œdema, which is really a heart condition and not dependent on any change in the lung tissue itself. Œdema of the lungs usually indicates a weakening or partial paralysis of the left side of the heart, so that the right ventricle pumps more blood into the lungs than the left can properly distribute, and the greatly increased tension in the pulmonary vessels causes an extravasation of serum from the capillaries into the lung tissue. The patient is suddenly seized with dyspnœa, and coughs up large quantities of frothy, blood-stained fluid. The ear applied to the chest hears many coarse bubbling râles.

The treatment of these two conditions brooks no delay. Hypodermic injection of gr. $\frac{1}{15}$ of strychnine with gr. $\frac{1}{20}$ of digitalin, supplemented by a diffusible stimulant such as ether, should be given at once. Large repeated injections of glonoin with strychnine are highly approved. Immediate venesection and the withdrawal of 400 to 500 c.c. of blood may be required. As soon as the immediate danger is over, the most useful drug to prevent further attacks is morphine, which acts as a true cardiac stimulant by cutting off afferent irritating impulses from the periphery which serve to embarrass the susceptible heart.

Thrombosis and Embolism.—Femoral thrombo-phlebitis is a rather infrequent sequel to operative procedures, but still occurs with more or less persistent regularity in the service of every surgeon who is constantly operating. This complication is justly classed by Maurice Richardson among the "unavoidable calamities following surgical operation," for while theoretically it may be prevented, yet, in the light of our present-day knowledge, it appears to be practically unavoidable. Thrombosis of the femoral vein appears without warning one to four weeks after the time of operation and, indeed, even after the patient has been discharged from the hospital as well. This complication is seen most commonly after abdominal operations and in the vast majority of cases in a patient who is having an uninterrupted convalescence with no evidence of infection about the operative site. The left leg is about twice as often affected as the right and the first symptom is pain, usually severe, in the groin and in the calf muscles. The temperature rises to 100°, and rarely above 101° F. There is almost invariably a moderate degree of leucocytosis. Examination discloses distinct tenderness over the femoral vein and often along the course of the external saphenous. The vein can be felt to be thrombosed, and the leg soon begins to swell, with or without pitting on pressure.

The exact etiology is uncertain. The cases practically always terminate in recovery, so that there has been very little opportunity for studying the early lesion post mortem. The rise of temperature associated with a polynuclear leucocytosis speaks for an infective process, though it is difficult to conceive of its source of origin in the majority of cases. The suggestions have been advanced that the predisposing or actual cause is the bruising of the epigastric veins by the pressure of retractors, or that it is brought about by a dyscrasia of the blood in anæmic individuals, a condition which favors clotting in the vessels. Its more frequent occurrence in the left leg is attributed to the greater length of the left common iliac vein, to its passage beneath the right common iliac artery, and possibly to pressure upon this vein by a distended sigmoid flexure or rectum.

In the treatment prophylactic measures will consist in every effort to maintain strict asepsis, together with care in the use of retractors, which may well be protected with a few layers of gauze. After the lesion has developed the leg should in the first place be handled as little as possible because of the danger of dislodging a portion of the thrombus and so inducing a pulmonary embolism. Recovery usually ensues upon absolute rest in bed, the application of belladonna and mercury ointment, wrapping the leg in cotton, and elevating it upon pillows. The patient should not leave the bed until all active symptoms have subsided. If the leg remains swollen during convalescence an elastic stocking will afford much comfort.

Pulmonary embolism is secondary to thrombosis in a peripheral vein or to a vegetative endocarditis of the right side of the heart. Occasionally, in severe fractures with contusion of the bone, particles of fat escape into the circulation and give rise to a fat embolism in the lungs.

Pulmonary embolism comes on most suddenly and the patient is seized with pain in the chest, gasps for breath, and may fall back lifeless before any possible aid can be summoned. Pulmonary embolism may be the initial symptom of a femoral thrombosis, even before local evidences have developed in the leg. A most interesting example of this occurred in the writer's practice, in which a woman was seized with the characteristic symptoms of pulmonary embolism which was not fatal. As soon as she was able to speak she told in a most graphic manner how she felt "something break" in the region of the left groin, followed by a sensation of a lump passing through the heart and finally lodging in the right side of the chest. Examination showed a beginning femoral thrombosis of the left leg and an area of dulness and atelectasis in the right lung.

The lodgment of an embolus in the lung gives rise to a hemorrhagic infarct and the patient will expectorate almost pure blood for some hours. If the embolus is infected the septic infarct will break down and an abscess of the lung result.

As regards treatment of pulmonary embolism the successful outcome depends more on the extent of the lesion than on any method we possess of cure. Our chief aid lies in the administration of oxygen inhalations and stimulation of the respiratory centres with strychnine, while after the immediate danger is over the patient should be quieted with morphine and every effort made to prevent further damage.

Acid Intoxication.—Following upon operations in which a general anæsthetic has been employed there occasionally develops a severe toxæmia of a peculiar type which is almost invariably fatal. Bevan, of Chicago, has been particularly interested in collecting cases from the literature to report along with very carefully studied material from his own clinic. The condition which is here described has been reported under various titles, such as "Hepatic Toxæmia," "Fatal Acetonæmia," "Acute Fatty Degeneration of the Liver following Anæsthesia," etc. The symptoms appear in from twelve hours to five days after operation and the first indication that all is not going well is the gradual development of restlessness and a mild degree of delirium. Associated with this there is noticed a sweetish odor to the breath. Dyspnœa of a peculiar type develops, known as Kussmaul's air hunger, characterized by rapid and deep breathing. Vomiting is often a pronounced feature. A slight degree of icterus may be noted in the sclerotics, and the extent of liver dulness is found to be distinctly diminished. The temperature is moderately elevated and the pulse becomes frequent and weak.

The following résumé is quoted directly from one of Bevan's monographs and covers in a detailed manner the various features of the condition as far as they are known at the present writing:

"1. Anæsthetics, especially chloroform (ether to a very limited degree), can produce a destructive effect on the cells of the liver and kidneys and on the muscle cells of the heart and other muscles, resulting in fatty degeneration and necrosis, very similar to the effects produced in phosphorus poisoning.

"2. The constant and most important injury done is that to the liver.

"3. This injury to the liver cells is in direct proportion to the amount of the anæsthetic employed, and the length of the anæsthesia.

"4. Certain individuals exhibit an idiosyncrasy or a susceptibility to this form of poisoning which it is difficult to explain.

"5. There are certain predisposing causes which favor this destructive effect of chloroform, among which are: (*a*) Age—the younger, the more susceptible; (*b*) causes which lower the general vitality of the individual and probably the vitality of the liver cells, such as diabetes, previous recent anæsthesias, infections from pus germs, diphtheria, intoxications from a dead fœtus in the uterus, a gangrenous mass in the abdominal cavity, etc.; (*c*) exhaustion due to hemorrhage; (*d*) exhaustion due to starvation; (*e*) exhaustion due to wasting diseases, such as carcinoma; (*f*) lesions which have resulted in extensive fatty degenerations, such as occur in the limbs in infantile paralysis; (*g*) chronic diseases involving both liver and kidney, such as cirrhosis and nephritis.

"6. As a result of this fatty degeneration and necrosis of the liver cells, toxins are produced either from the liver cells themselves or as a result of the failure of these cells to eliminate substances which, under normal conditions, they eliminate, but which under these abnormal conditions they fail to do, and these substances, therefore, may accumulate and produce toxic effects.

"7. These toxins produce a definite symptom-complex which makes its appearance from ten to one hundred and fifty hours after the anæsthesia. This symptom-complex consists of vomiting, restlessness, delirium, convulsions, coma, Cheyne-Stokes respiration, cyanosis, icterus in varying degree, and usually terminates in death.

"8. It is probable that milder degrees of this poisoning are recovered from, and that the transient icterus noticed after chloroform anæsthesia without other evident cause is due to such poisoning, and many cases which exhibit restlessness, fright, mild delirium, drowsiness, etc., after anæsthesia may be due to the same cause.

"9. This disease is a hepatic toxæmia; the toxins producing it are hepatic toxins; and possibly the previous condition making its development easily possible should be described as liver insufficiency. Just as we have for a long time recognized a condition, uræmia, in which we find arising from a variety of noxious agents, anæsthetics, poisons, infections, pregnancy, etc., affecting the secreting cells of the kidney and preventing their normal function, a pathologic condition, accompanied with a certain definite symptom-complex, so we must now, we believe, recognize a condition involving the liver in which we find from a variety of noxious agents (anæsthetics, poisons, infections, pregnancy, etc.), affecting the secreting cells of the liver and preventing their normal function, a pathological condition which we must describe as hepatic toxæmia accompanied with a certain symptom-complex and showing certain changes post mortem.

"We believe that the condition of acute fatty degeneration of the liver with resulting hepatic toxæmia is as definite a pathologic entity as is acute pancreatitis with fat necrosis.

"10. As by-products in this toxæmia, but not as the essential poisons, are found acetone, diacetic acid, and beta-oxybutyric acid in the blood and urine.

"11. Post-mortem reveals fatty degeneration of the liver, fatty degeneration and mild degree of inflammation of the kidneys, and, in extreme cases, fatty degeneration of heart and other muscles. The lesion of the liver we believe to be the overshadowing and important one, and the one which is responsible for the symptoms and fatal result. The injury to the liver, in some cases, is so great as to result in practically a total destruction of the organ.

"12. Somewhat similar hepatic toxæmias resulting from fatty degeneration of the liver cells occur in other conditions, and are accompanied with very similar symptoms. Such conditions are phosphorus poisoning, diabetes, puerperal eclampsia, and acute yellow atrophy of the liver.

"13. This fatty degeneration of the liver with hepatic toxæmia following anæsthesia is almost invariably due to chloroform in the fatal cases. Ether is seldom the cause of a death of this kind.

"14. This serious and even fatal late effect of chloroform which has heretofore not been generally recognized must still further limit the use of this powerful and dangerous agent.

"15. The possibility of the development of hepatic toxæmia makes chloroform distinctly contra-indicated in those cases in which there exist the conditions which seem to favor its development, *i.e.*, diabetes, sepsis, starvation, hemorrhage; the presence of intoxication from dead material; the presence of fatty degenerations, as already cited, after infantile paralysis, and lesions of the liver. The susceptibility of children to this hepatic toxæmia must be recognized. That chloroform is capable of producing these serious late poisonous effects is a strong argument against its employment, and an argument in favor of the more general use of ether; and yet we are confronted at times with the Charybdis of ether pneumonia, on the one hand, and the Scylla of chloroform hepatic toxæmia, on the other.

"16. The recognition of this danger of hepatic toxæmia is a strong argument against the employment of chloroform for long anæsthesia, as it can be shown that a two-hour chloroform anæsthesia is almost invariably fatal to rabbits and guinea-pigs, from fatty degeneration and necrosis of the liver cells; and a two-hour chloroform anæsthesia in man is an exceedingly dangerous thing.

"17. These facts in regard to the late poisonous effects of anæsthetics and the fact that the dangers increase with the amount of the drug employed and with the length of the anæsthesia, form a strong argument in favor of rapid operating and in favor of limiting in every way possible the length of the anæsthesia and the dose of the anæsthetic. For example, time-consuming preparations of the patient should be made before, not after, anæsthesia. In the light of this present knowledge, no surgeon can claim, as some have in the past, that after the patient is once asleep, it makes no difference whether it requires one hour or two for the doing of an operation. In the light of this knowledge, for instance, three-hour breast amputations with the unnecessary ligation of fifty vessels become bad surgery.

"18. This problem seems to us a very important one and worthy of the most careful study and research. At present we are practically limited to chloroform and ether as general anæsthetics. Each has its danger; each has its special field in which one is safer than the other. We have, as a rule, heretofore employed chloroform in cases in which there was a previous lung or kidney lesion, and in children, with the idea that it was less likely to produce nephritis and pneumonia, and have used ether in the bulk of our work and felt that it was specially to be selected in heart lesions. We must now add new limitations, and attempt to determine by previous examination whether there is what might be called hepatic insufficiency, the condition present which favors the development of the late poisonous effect of chloroform on the liver. Another way of solving this problem would be the discovery of new anæsthetic agents, which do not carry with them these poisonous effects, or the employment of the present anæsthetic in such a way as to avoid these dangers."

Iodoform Poisoning.—A very perplexing symptom-complex occasionally arises following the use of iodoform as a dusting powder or when incorporated into drainage material. The condition generally sets in with anxiety, depression, and headache. The patient is unable to sleep and soon shows evidence of cerebral excitement with great restlessness which may pass into an active delirium not readily amenable to narcotics. The stage of excitement may deepen into a condition of coma, or a true melancholia may develop associated with hallucinations. A rarer result of the absorption of iodoform is deep sleep passing into stupor and collapse, without any symptoms of cerebral excitement. In some cases of iodoform poisoning a generalized scarlatinal skin rash develops. The pulse is much accelerated and it has been said that the body temperature may be moderately elevated even in the absence of any signs of sepsis.

Toxic effects from iodoform are usually said to occur more frequently in the aged, but children also are quite susceptible. The symptoms in general are not unlike those of acute thyroidism, and in this connection it is interesting to note that the thyroid secretion has been found to be increased to a very considerable extent by iodoform, as by other bodies which liberate iodine in the tissues. The toxic effect of iodoform cannot be entirely attributed, however, to the splitting off of iodine, as its action seems to be much more complex. After fatal poisoning the liver, kidneys, and heart muscle are generally found to have undergone fatty degeneration. Symptoms of iodoform poisoning are particularly apt to follow when the drug is used in brain surgery, and for this reason it had best be discarded in operations on this part of the body. The diagnosis of iodoform intoxication may offer practical difficulties, but whenever anomalous mental symptoms develop in a case in which iodoform has been used it is advisable to remove as much of the substance as possible, replace iodoform drains with plain gauze, and flush out any draining cavity with sterile salt water.

The treatment of iodoform poisoning consists in securing free elimination by purgation and the introduction of physiological saline solution into the tissues. The use of bicarbonate of soda has been advised in the hope that it will combine with the iodine and aid in its elimination. If suppression of urine occurs this must be appropriately treated by hot packs, etc.

Parotitis.—Acute inflammation of one or both parotid glands is a rare complication that may occur during convalescence from a surgical operation. Much interest attaches to this condition because of its relatively frequent occurrence after abdominal operations, particularly those involving the ovaries and testes. The enlargement appears rather suddenly from several days to several weeks after operation, the gland becomes swollen, hot, and tender, and the process generally leads to suppuration. The right parotid is more frequently affected than the left, but in about one-third of the cases both glands are involved. The etiology of this condition is certainly obscure. While the inception of the inflammation may depend, as some hold, upon a reflex disturbance, yet there is in every case an acute suppurative local process associated with severe constitutional symptoms. The rather frequent occurrence of parotitis with diffuse peritonitis speaks for a pyæmic process with a metastatic focus in the gland. In other instances, however, the bubo appears in a perfectly clean abdominal case. In this event it is quite possible, as has been suggested, that the infection comes from a dirty mouth. The location of the orifice of Stenson's duct on the buccal mucous membrane opposite the second molar tooth of the upper jaw renders the parotid gland possibly more susceptible to invasion with organisms from the mouth than are the other salivary glands. The part played by oral sepsis assumes more significance since it has been noted that parotitis is becoming relatively less frequent now that more attention is being paid to the care of the mouth.

The treatment of parotitis must be local and general. As regards the former, palliative measures rarely succeed, and an early incision with evacuation of the pus constitutes by far the best procedure. The constitutional symptoms require the usual treatment of an acute infection.

Fæcal Impaction.—In describing above the general preparation for an operation it was advised to cleanse out the intestinal tract by means of castor oil supplemented by flushing out the lower bowel. In the great majority of instances such a measure suffices. Occasionally, however, in a patient inclined to habitual constipation even a copious evacuation may leave much residue behind. Following the operation the period of intestinal atony, together with the abdominal discomfort and disinclination to go to stool, allows the fæces to become solidified. As a result the rectum may be filled with hard scybalæ and the patient begins to suffer discomfort in that region and has a desire to defecate which is not gratified. If the condition is not rectified the irritation produced may give rise to a watery diarrhœa consisting chiefly of the increased intestinal secretion which may escape about the hardened masses of fæces while they remain undislodged. The fæcal obstruction, furthermore, may become canalized and so allow the passage of intestinal contents from above. It is just such a contingency which is misleading, as the nurse will declare that the patient's bowels have moved well. The patient, however, is usually well aware of the fact that the rectum is not emptied and insists on being relieved. The contention is here made that fæcal impaction occurs more frequently than is generally recognized and that a digital examination of the rectum will often prevent several days of discomfort.

In the treatment of this condition it is not infrequently necessary to remove the offending material by means of the finger. The surgeon should always put on a pair of rubber gloves or at least a finger cot. This procedure is painful and should be preceded by efforts of a simpler nature. An enema consisting of ten ounces of olive oil with two ounces of glycerin is often very effectual. It should be retained, if possible, for fifteen or twenty minutes.

Should this enema be ineffectual it may be repeated in four hours and then followed in the course of an hour with a large water enema containing two ounces of epsom salts and four ounces of glycerin. Ox-gall by many is regarded of especial use. The bowels ought to be particularly watched during the next few days so as to ascertain that the intestinal tract is thoroughly cleared.

Secondary Hemorrhage.—The failure properly to tie off all bleeding points may be an act of gross carelessness and negligence. Conditions do occasionally arise, however, when even the most studied art on the surgeon's part fails to prevent this complication. The most common cause of unavoidable secondary hemorrhage is found in a diseased condition of the vessel wall, which permits the latter to give way at or near the ligature before the blood thoroughly clots in the stump of the vessel. Bleeding may be also due to the slipping of a ligature or, on the other hand, to the fact that the suture has been tied so tightly as gradually to cut through the vessel wall.

The employment of the mass ligature is to be avoided whenever possible as it is not infrequently ineffective. Hemorrhage may ensue upon suture work on the intestines if abdominal distention occurs and if the sutures are not well reinforced.

Secondary hemorrhage may be due to a general oozing or to a rupture of a relatively large vessel. The blood may freely collect in the body cavity or may be confined in the tissues, giving rise to a hæmatoma. The diagnosis between rapid hemorrhage and shock offers some practical difficulty. In both conditions the pulse becomes more frequent and of smaller volume, but in hemorrhage this change is usually more gradual and progressive than in shock. shock there is frequently a tendency to reaction which is not observed in hemorrhage. Probably the best guide is the patient's general condition. In shock there is pallor with lividity while the intellectual faculties are sluggish in their operation. The pallor of hemorrhage is more pronounced, and the patient is alert and anxious. A paucity of red cells is shown in the blood picture in these cases. Physical examination in cases of hemorrhage may reveal the presence of free fluid in the cavity, or a prominent mass makes its appearance.

There is only one reliable form of treatment for post-operative hemorrhage and that is to expose the operative area and secure the bleeding vessel. If the bleeding comes from a mass of veins each of which cannot be isolated and tied, or if they lie in close proximity to some important structure as the ureter, which might be included in a mass ligature, the bleeding will have to be controlled by tight packing with gauze.

Sampson, of Albany, has proposed and made use of an ingenious scheme to control hemorrhage following pelvic operations. This is done by opening the lower end of the abdominal incision without anæsthesia and then introducing a sterilized proctoscope through the opening down into the pelvis. Sterile gauze is then tightly packed into the pelvis and counterpressure is made by tightly packing the vagina.

Status Lymphaticus.—This is a rather rare constitutional condition, occurring chiefly in children in whom there exists an enlargement of the thymus gland with hyperplasia of the lymphatic tissues throughout the body. Special interest attaches to this condition because the subjects of this lymphatic constitution have a diminished vital resistance and are very liable to fatal collapse under ordinarily very inadequate exciting causes. In many cases of sudden death of children during anæsthesia the thymus gland is found much enlarged. The exact relationship of this condition to sudden death has not been explained, but it is generally believed that individuals with this hyperplasia have lowered powers of resistance and are particularly liable to paralysis of the heart. The diagnosis of the lymphatic constitution is always difficult. The most important features are a general enlargement of the superficial glands, hypertrophy of the tonsils, increased dulness over the sternum (thymus enlarged), with signs of enlargement of the mesenteric glands. In addition, the patients are often poorly developed and may be infantile in aspect.

ANÆSTHETICS AND THE PRODUCTION OF GENERAL ANÆSTHESIA.

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Boston, Massachusetts.

I. INTRODUCTION.

The necessity for some agent to relieve the pain incident to surgery had been realized for centuries, and in the writings of Herodotus, Dioscorides, Pliny, and Homer mention is made of attempts by the ancients to accomplish this purpose by administering mandragora, poppy, henbane, or cannabis indica. As surgical skill advanced, this necessity became greater, and the medical literature of the early part of the last century refers to the horrors of surgery, and to the attempts to produce analgesia by the use of hypnotism, alcohol, and opium.

Although ether was discovered in 1540 by Valerius Cordus, and nitrous oxide by Priestley in 1774, their anæsthetic properties were not recognized until many years later.

In 1842 Dr. Crawford W. Long, of Georgia, administered ether and performed a painless operation for the removal of a tumor of the lower jaw. But he did not realize the importance of his work, and made no attempt to publish it and thus to offer relief from the sufferings of thousands.

In 1844, at Hartford, Conn., Horace Wells, having seen a demonstration of "laughing-gas" by G. S. Colton, then a wandering lecturer, determined to use it in his dental practice, but in a demonstration at the Massachusetts General Hospital he failed to produce a satisfactory state of anæsthesia in his patient, and died in 1848. After Dr. Wells' death nitrous oxide was little used until 1867, when Colton again introduced it.

In 1846, W. T. G. Morton, a young dentist, and at one time a partner of Horace Wells, realizing the desirability of a more stable anæsthetic than nitrous oxide, determined to try ether, and on October 13, 1846, at the Massachusetts General Hospital, Dr. J. C. Warren operating, Morton successfully administered ether. The apparatus used was a glass globe-shaped inhaler with funnel-shaped mouth-piece (Fig. 67), although in many subsequent administrations the sponge shown in Fig. 68 was used.

Ether now entirely supplanted nitrous oxide, and the news of its discovery spread to all parts of the civilized world, particularly to England.

In 1847 Dr. J. Y. Simpson, of Edinburgh, first used chloroform as an anæsthetic, and from that time until very recently most of the important improvements in method and apparatus for administering gas, ether, and chloroform, appear to have come from England. This was probably due to the fact that chloroform was soon recognized as a dangerous drug, demanding more than ordinary care in its administration. Several deaths occurred under its use, and the attention of surgeons and dentists was directed to inventing methods and apparatus for the safe administration of chloroform, and thus also to gas and ether.

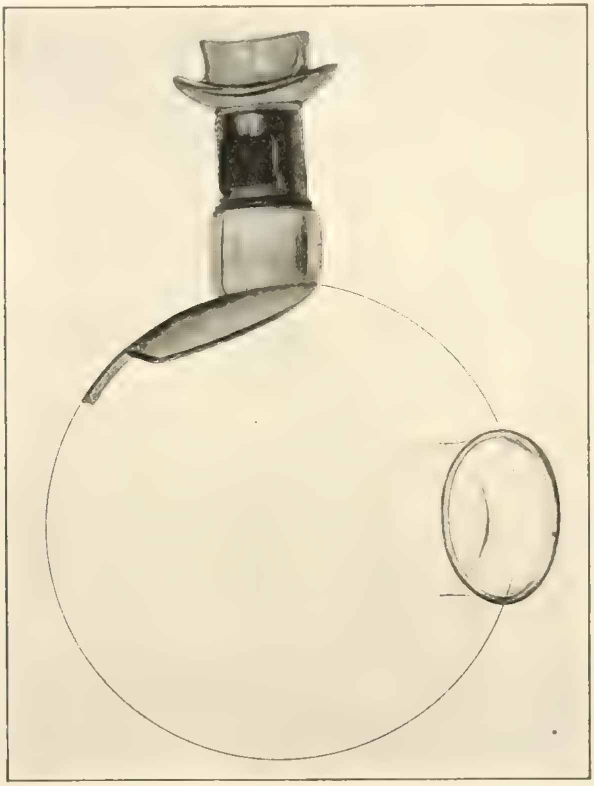

Fig. 67.—Morton's Original Ether Inhaler.

In the mean time the use of ether continued in the United States, and, as it was found to be safe, no notable improvements in method or apparatus were introduced, a folded towel or sponge ordinarily being used for the administration.

In 1858 Dr. John Snow, of London, invented a regulating chloroform inhaler, and also published the results of his extensive investigations of the action of ether and nitrous oxide.

In 1862 Mr. J. T. Clover, of London, did some notable work on the physiology of chloroform and introduced an inhaler for its administration.

In 1863 Colton, having used nitrous oxide extensively in New York, went to Paris, and from there the use of the gas in dentistry was introduced by Dr. Evans into England. Clover continued his work on anæsthetics, paying now particular attention to the administration of nitrous oxide and of ether. In 1876 he perfected his combined nitrous-oxide and ether inhaler, thereby making two notable advances in the science of administering anæsthetics: First, the administration of nitrous oxide as a preliminary to ether; and, second, the administration of ether by the closed method (*i.e.*, with limitation of air).

The next considerable advance was made by Dr. Frederic W. Hewitt, of London, who in 1886 began his experiments in administering nitrous oxide with oxygen, and in 1894 perfected his valuable apparatus for this purpose.

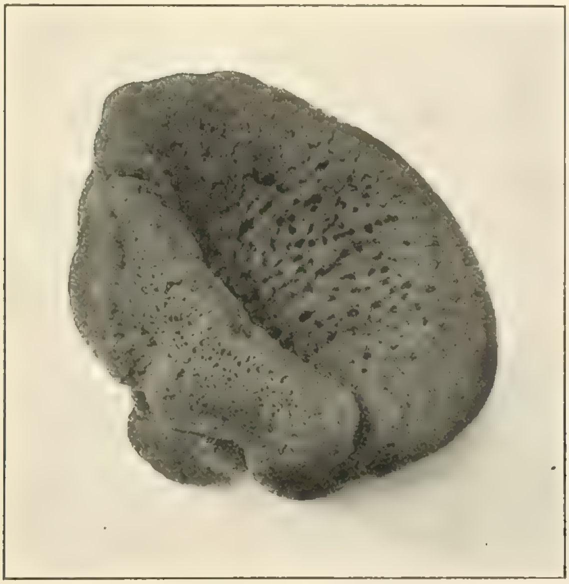

FIG. 68.—Morton's Sponge, Used in Early Administration of Ether.

In 1897 ethyl chloride, in common use as a local anæsthetic, was observed by Billeter, a Swiss dentist, to produce light degrees of general anæsthesia when sprayed upon the gums. This led to the first considerable use of the drug as a general anæsthetic, by Lotheisen (Vienna), in 1898.

In 1895 Dr. Rolland, of Bordeaux, introduced somnoforme.

In 1895 Dr. Schleich, of Berlin, introduced his three anæsthetic mixtures of ether, chloroform, and petroleum ether. The principle upon which these mixtures were made was that the boiling-point should be about 98° F., or near the body temperature, thus securing uniform absorption and elimination with nearly synchronous evaporation of the ingredients. These mixtures were introduced as improvements upon the A. C. E. (alcohol, chloroform, ether) and C. E. (chloroform, ether) mixtures then extensively used in England.

In America the most noteworthy advances in anæsthesia were the introduction of "anæsthol"* by Dr. Willy Meyer, of New York, in 1898, and the Bennett combined nitrous-oxide and ether inhaler by Dr. T. L. Bennett, of New York, in 1899.

Dr. Bennett's combined gas and ether inhaler for the administration of these agents separately or in combination was suggested by Clover's apparatus, but is distinctly an improvement upon it.

In England for many years the administration of anæsthetics has been made a profession by medical men. There are societies of anæsthetists, and systematic teaching is in vogue at the large hospitals and medical schools. Much writing is also done on the subject of anæsthesia.

In America, until very recently, the interest of the profession in anæsthesia has been feeble. Systematic instruction is omitted from the curricula of most of the hospitals and medical schools of this country, and the average practitioner starts with a meagre knowledge of this important subject.

The object of this paper, therefore, is to furnish such practical details as will enable the reader to get a working knowledge of the principles and methods of administering the more commonly used anæsthetics.

II. PREPARATION FOR SURGICAL ANÆSTHESIA.

Preparation of the Patient.—The amount of preparation necessary for patients about to inhale anæsthetics varies with the duration and depth of the required anæsthesia, but, generally speaking, they do better if the stomach, rectum, and bladder are empty.

In light anæsthesias consisting of a simple administration of nitrous oxide, for example, little or no preparation may be necessary. Certain precautions, however, should be taken before the administration of any general anæsthetic: The mouth should be clear of any foreign body that could be swallowed or inhaled, the nose should be cleared by blowing, and the clothing about the neck and waist should be loosened.

The longer and more profound administrations in major surgery require a careful and thorough preparation which it might be necessary to begin weeks beforehand. A weak patient, for example, might need a long course of nourishing food and hygienic treatment before he would be in a fit condition for

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* "Anæsthol" is a mixture of

Ethyl chloride	17.00 volumes
Ether	56.75 "
Chloroform	43.25 "

with a boiling-point of 40° C. (104° F.) It is based on Schleich's principles, but is more efficient than either of the mixtures which he advocated, and is an improvement on the A. C. E. mixture (alcohol 1 part, chloroform 2 parts, ether 3 parts).

operation; a diabetic might require dieting until the amount of sugar in the urine had been reduced as much as possible.

It is essential in every major administration that the stomach, rectum, and bladder be empty at the time of operation, and thus degrees of starving and purging varying with the strength of the patient may be necessary. A weak and anæmic woman should be lightly dieted and gently purged, but a strong and plethoric man will take an anæsthetic better if he be well starved and purged.

Generally speaking, for twelve hours before the administration of the anæsthetic all solid food should be withheld and the stomach should be empty at the time of operation. Emergency cases may require the use of the stomach tube, which may often be left in the stomach during the operation, as, for example, in cases of intestinal obstruction with fæcaloid regurgitation. Young children may surreptitiously obtain solid food before anæsthesia and may require watching on this account to prevent it. Many serious accidents have occurred from the vomiting and inhalation of food by anæsthetized patients.

A good way of emptying the rectum is to give a purgative at noon on the day before operation and an enema at eight or nine o'clock the same evening. It will then not be necessary to disturb the patient, in the early hours of the morning of the operation, to give an enema. As before stated, the amount of purgation must be increased or diminished according to the patient's strength.

In preparing to administer ether by the rectum, Cunningham advocates the use of full doses of magnesium sulphate the day before operation, and a large cleansing enema the morning of operation, to be repeated one-half hour before commencing the administration.

Patients should always empty the bladder or be catheterized immediately before operation.

The mouth should be cleaned by thoroughly brushing the teeth and using an antiseptic mouth wash and gargle just before operation. The very foul teeth of some hospital patients may require systematic cleaning by a dentist before the administration of the anæsthetic. This is especially true in the use of ether, as the mucus developed by it may become infected by bacteria from the mouth and possibly inhaled, thus causing a septic bronchitis. The secretion of mucus and saliva is increased during the administration of the anæsthetic.

Mixed Anæsthesia.—The preliminary administration of narcotic drugs, such as morphine with or without atropine, hyoscine, scopolamine, chloral, etc., to patients about to be anæsthetized with ether or chloroform, is called "mixed anæsthesia." The hydrobromate of hyoscine, gr. $\frac{1}{100}$, given half an hour before the anæsthetic, has been found by some to produce tranquil anæsthesia and delayed, but satisfactory, recoveries. The same is true of the hydrobromate of scopolamine, gr. $\frac{1}{100}$, given an hour before the anæsthetic, and a dose of morphine given half an hour before. The drugs are administered hypodermically. Although successful in many cases, hyoscine and scopolamine do not seem to be entirely without danger, owing to their tendency to depress too much the respiration and the nervous system.

Morphine with atropine is safer to use. These drugs should be given in rather small doses about half an hour before the anæsthetic. Women will not require more than

Morphine	gr. $\frac{1}{8}$ to $\frac{1}{6}$
Atropine	gr. $\frac{1}{200}$ to $\frac{1}{150}$

while men do well with

Morphine	gr. $\frac{1}{6}$ to $\frac{1}{4}$
Atropine	gr. $\frac{1}{150}$ to $\frac{1}{100}$

The *advantages* of mixed anæsthesia are:

Calming and tranquillizing the patient before anæsthesia.

Diminution of the secretion of mucus and saliva during etherization, thus avoiding inflammation of the respiratory passages following ether anæsthesia.

Lessening of the amount of ether or chloroform necessary to control the patient.

A tendency to produce quiet anæsthesia by depressing the respiration.

A tendency to lessen post-anæsthetic sickness by causing the patient to sleep after withdrawal of the anæsthetic.

A tendency to produce more complete muscular relaxation.

The *disadvantages* are:

If too much of the anæsthetic is used considerable depression of the respiration, owing to hypernarcosis, may result.

It may delay recovery an unnecessarily long time.

Mixed anæsthesia should not be used as a routine. The cases should be selected, and the doses of the drugs made as small as possible. Generally speaking, it may be used for most laparotomies, owing to the tranquil breathing produced. It is also particularly useful in operations like extirpation of the tongue, where the giving of the anæsthetic has to be interrupted for varying periods of time. Mixed anæsthesia should be omitted in weak patients and in cases of morphine idiosyncrasy; also in short operations that do not require very complete muscular relaxation or tranquil respiration.

Certain emergency cases, notably of appendicitis, peritonitis, intestinal obstruction, etc., may present themselves for operation after the patient has recently had large doses of morphine on account of pain. Unless this be known, and the amount of the anæsthetic proportionately lessened, dangerous respiratory depression and hypernarcosis may result during anæsthesia.

Morphinists will be found hard to control unless they are given suitable doses of morphine before anæsthesia.

Morphine should never be given after anæsthesia until all the reflexes have returned and the patient is fully conscious; otherwise recovery may be long delayed and the proper clearing of the respiratory passages of mucus be prevented.

Mixed anæsthesia should be used with great caution, if at all, in children.

Atropine alone is useful when ether is used. It may be given hypodermically or by mouth in doses of gr. $\frac{1}{300}$ to gr. $\frac{1}{100}$ five or ten minutes before beginning the administration. It prevents the excessive secretion of mucus and saliva, and by its stimulant action supports the heart, thus producing a good facial color which might prove to be deceptive.

The *preliminary administration of stimulants* may be necessary in cases of shock, exsanguination, or exhaustion requiring anæsthetics. As a rule, rectal stimulation by an enema of salt solution, brandy, and coffee, intravenous infusion with salt solution, or alcoholic stimulation by mouth is more effective in these cases than the liberal use of hypodermic injections of strychnine, digitalis, etc.

Certain cases of cardiac disease may require a course of treatment by appropriate stimulants for several weeks before the administration of an anæsthetic and the performance of the operation.

Before an anæsthetic is administered, the history of the patient's previous anæsthesias, if any, should be learned. If, for example, there is a history of marked excitement and struggling while "going under" chloroform, anæsthesia may be induced by gas and ether and excitement thus avoided. If much post-anæsthetic sickness has followed an administration of ether, it may be avoided this time by giving nitrous oxide and oxygen.

The anæsthetist should be satisfied regarding the state of the heart and arteries and of the lungs, either examining them himself or receiving the assurance of the doctor in charge that they are in good condition. The existence of acute bronchitis, or a head cold, is often enough to cause postponement of anæsthesia, and the patient should always be questioned as to cough, sore throat, coryza, etc. Besides this, the mouth should be examined for the presence of false teeth, enlarged tonsils, adenoids, cleft palate, etc.; the nose for enlarged lower turbinates, deviated septum, or other source of nasal obstruction; and the chest expansion should be tested by causing the patient to take a full breath. In this way we can prepare for any existing impediment of breathing and for any danger to the circulation. Such an examination usually reassures a patient rather than frightens him.

The *urine* must be examined particularly for sugar, albumin, or casts in the sediment.

It is unwise to administer anæsthetics to patients of either sex except in the presence of a third person. Men may become violent and require restraint, and the erotic dreams and evil intentions of women have given rise to false accusations and legal complications.

Preparation and Equipment of the Anæsthetist.—A little care in the preparation and equipment of the anæsthetist will prevent much delay and confusion during the operation. An adequate supply of whatever anæsthetic agent is to be used should be at hand.

All apparatus should be clean, and should be tested before using to make sure that it is in working order.

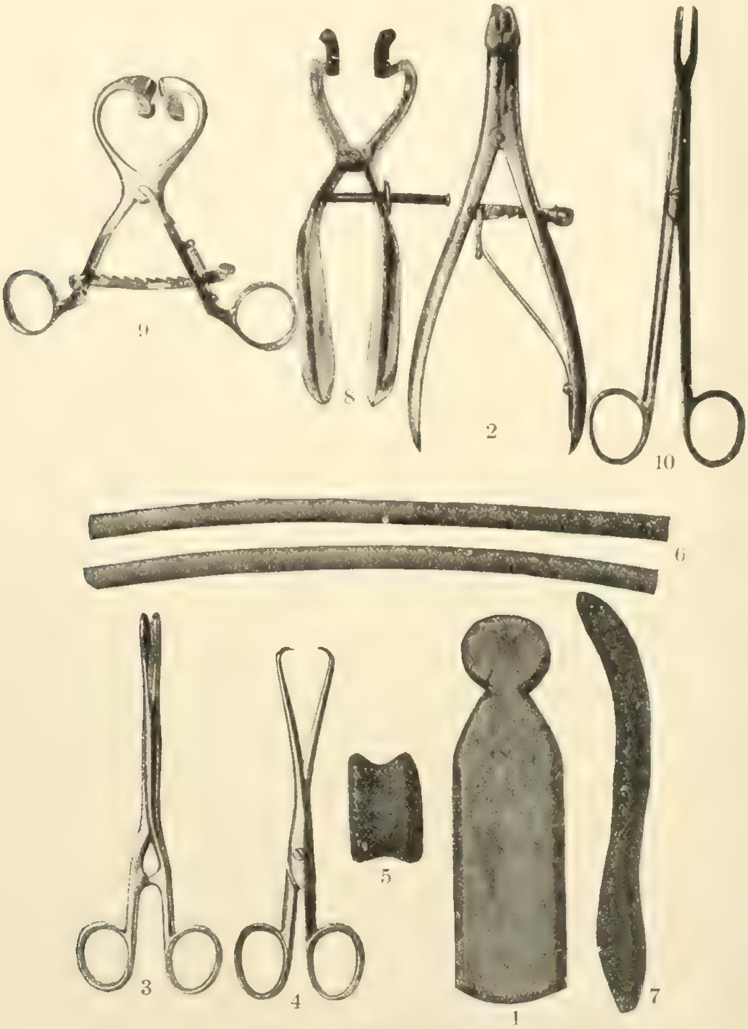

Fig. 69.—Various Forms of Mouth Gags, Tongue Forceps, etc.

An administration should never be started without a gag and tongue forceps being at hand. There are many forms of gags. The wedge (Nos. 1 and 7, Fig. 69) is useful for prying open clenched teeth. Dr. Bennett's mouth-opening gag is also serviceable (No. 2, Fig. 69). Other forms of gags are shown in Fig. 69 (Nos. 8 and 9). Tongue forceps should be made in such a manner as to injure the tongue as little as possible. The useful forms are the smooth-jawed kind (Nos. 3 and 10, Fig. 69) or the tongue-piercing kind (No. 4, Fig. 69). If prolonged drawing forward of the tongue becomes necessary one should substitute for the forceps a silk or strong catgut suture which may be passed through the middle of the tongue by a glover's needle and then knotted.

Mouth props or bite blocks should also be at hand. They are useful in all intra-oral operations and for holding open the mouth when nasal obstruction exists (5, Fig. 69). Two pieces of rubber tubing, three-eighths of an inch in diameter and from two to six inches long, that may be passed along the floor of the nares to admit air, are useful in nasal obstruction (6, Fig. 69).

A small basin for vomiting during or after operation should be at hand; also a moistened towel and throat sponges wrung out in warm water. The throat should not be wiped out with dry gauze or sponges, as it may brush off the epithelium and cause pharyngitis.

A hypodermic syringe that is in working order, and tablets or, better yet, fresh solutions of strychnine, digitalis, cocaine, adrenalin, brandy, etc., should be a part of the equipment, but should not be used too readily. Oxygen and aromatic spirits of ammonia are often serviceable.

In certain operations—for example, intracranial operations—it may be necessary for the anæsthetist to sterilize his hands and apparatus and to wear a sterile gown. If this is not done, great care should be taken not to contaminate the field of operation and to keep the hands and apparatus as clean as possible.

Except in large hospitals, where smooth-running trucks and plenty of assistants are available, it is preferable, from every point of view, to arrange the patient comfortably on the operating table and there to begin the administration. Few patients will object to this when the reasons for it are explained to them. In these cases the instruments may be covered and the surgeon and his assistants keep out of sight. The anaesthetizing of patients at a distance from the operating-room is undesirable and often dangerous. The moving and jolting during transportation prevent a smooth anaesthesia and arouse the tendency to vomiting and the partial recovery of consciousness. Furthermore, the patient will be kept under the anaesthetic a considerably longer time than if the administration had been started on the table; and if respiratory difficulties—such as spasmodic arrest of respiration—should occur during transportation, trouble and delay in treating them will result.

The patient should be made as comfortable as possible on the table. As many pillows as required should be allowed, and the feet and chest should be well covered. A small pad or pillow placed at the small of the back will prevent the lame back that so frequently follows operations. The elbows of the patient should be allowed to rest on the table, and attendants should be prevented from wrapping up the arms in such a way as to constrict the chest and prevent free expansion. Anaesthetics lower the body temperature, and therefore patients should be covered sufficiently to protect them from draughts and cold, but not so as to cause sweating, which may be weakening and increases the liability to catch cold.

Heaters and hot-water bottles placed close to anæsthetized patients should be carefully wrapped in blankets and watched. Unless great care is exercised it is better to dispense with them altogether, as hot-water-bottle burns are often serious and frequently expose the attendants to suits at law and sometimes heavy damages.

It is very important to reassure the patient and to put him in a good frame of mind before starting the anæsthesia. An attendant or friend may be allowed gently to hold the patient's hand, and quiet should prevail in the room. Talking, hurry, confusion, and noise of any kind act on the sensorium of a semi-anæsthetized patient in an unfavorable manner, besides often preventing the anæsthetist from hearing the respiration.

In order to reduce to a minimum the length of anæsthesia, the order to begin it should not be given until the surgeon and his assistants are nearly or entirely ready to commence operating.

III. ADMINISTRATION OF ANÆSTHETICS.

The more commonly used anæsthetic agents are nitrous oxide, ethyl chloride, somnoforme, ether, chloroform, and mixtures of chloroform and ether.

In describing the administration of these agents the essential points in their chemistry, physical properties, and physiological effects will be considered; also their relative safety and the symptoms, dangers, and after-effects caused by them.

Nitrous Oxide.

Nitrous oxide is sold in heavy steel cylinders containing the gas in liquid form and under great pressure. When it is liberated from the cylinder, conversion into the gaseous form takes place, with the production of intense cold. This often interferes with the working of the apparatus, the outlet of the cylinder or the tubing becoming plugged with frost. English cylinders are superior to American ones in that they are made so as to lie flat on the ground, the gas being liberated with the foot, by means of a toothed key (see Fig. 72). They are sold in twenty-five- or fifty-gallon sizes, which are more convenient for transportation than the one-hundred-gallon size, which is the smallest supplied by American dealers. American cylinders have to be worked by a hand key in the upright position and thus require a special stand, or they have to be held by an assistant (Fig. 70).

Nitrous oxide is a colorless gas, heavier than air, with an almost imperceptible taste and odor. Cylinders containing it will explode if exposed to too high a temperature.

Nitrous oxide is a true anæsthetic and does not produce its effects by asphyxia, as is proved by its admistration with large percentages of oxygen, which prevents, approximately, at least, cyanosis, jactitation, and other asphyxial symptoms, and yet controls the patient. It cannot, however, be breathed pure for more than fifty or sixty seconds without producing asphyxia. It increases the rate and depth of respiration, accelerates the heart's action, and causes a rise in blood pressure. If its administration be pushed to the point of producing true asphyxia, respiration will cease while the heart continues to beat.

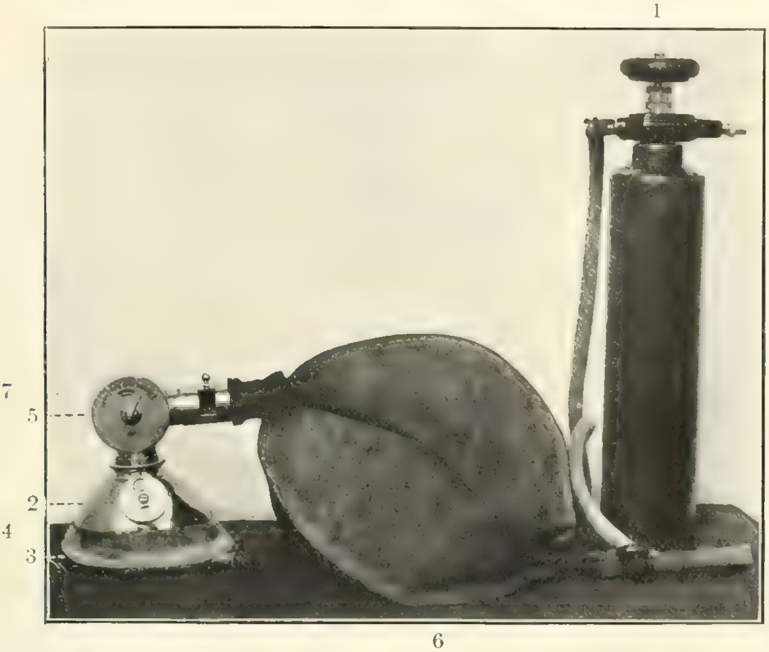

Fig. 70.—Bennett's Gas Inhaler.

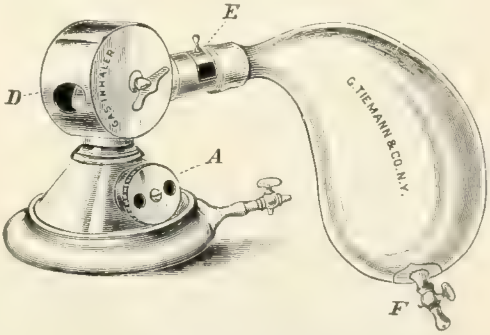

Fig. 71.—Diagrammatic View of Bennett's Gas Inhaler.

Nitrous oxide used as a preliminary to ether, or for short operative procedures requiring a single administration, as in dentistry, is the safest anæsthetic known. After a search of the literature covering a period of twenty-seven years, Hewitt could find only seventeen cases in which death had been due to nitrous oxide.* Combined with oxygen, nitrous oxide is even safer, and, according to Hewitt, produces the safest possible form of anæsthesia.

* Hewitt's "Administration of Anæsthetics," p. 227.

But the continuous inhalation of nitrous oxide with air or oxygen for the longer periods of time required by major surgical operations is dangerous. Alarming asphyxial symptoms may develop rapidly and deaths have been known to occur. Bennett says of this form of anæsthesia in long operations: "It seems probable that its general adoption would lead to a mortality more nearly approximating, if not exceeding, that of ether or chloroform."*

Gas is so easily eliminated from the lungs that in order to be effective it must be made partially to replace the air in the lungs, and the access of fresh air to the lungs should be prevented during the first few inhalations. The practical difficulty is not from giving the patient too much gas, but from allowing too much air, thus delaying anæsthesia. An apparatus, therefore, must be so made as to exclude atmospheric air and to replace the air in the lungs with gas. Such are Hewitt's or Bennett's gas inhalers.

Bennett's gas inhaler (Figs. 70 and 71) consists of:

1. The metal face-piece (2) with inflatable rubber rim (3) to exclude air, and aperture *A* to admit air.

2. The gas chamber (5), in which are an inspiratory and an expiratory valve, and a thumb-screw, by turning which they may be thrown out of action.

3. The gas bag (6), which is connected by a tube with the gas cylinder, and in which the gas is confined by a stop-cock which at the same time opens the air-tap (7).

Before beginning a gas administration, difficulties and possible failure may be avoided by the habitual observance of certain precautions, viz.:

1. Test the apparatus and make sure that it is in working order.

2. Be sure that the cylinder contains enough gas. This may be determined accurately by weighing the cylinder and comparing its weight with that marked on the label (*i.e.*, weight when full), or roughly by percussing the cylinder with some heavy metal object. Empty cylinders give a hollow sound; cylinders containing gas, a liquid sound.

3. Gas should be cautiously turned on from newly charged cylinders, as it is apt to come with a rush, frightening the patient or bursting the tube or the gas bag. It is well to blow off a little gas from a newly charged cylinder before beginning the administration.

4. The cylinder connection, which connects the tube leading to the gas bag with the cylinder, should be firmly screwed in place, and a leather washer used at the mouth of the cylinder to prevent the escape of gas at that point.

5. Before turning on the gas be sure that the stop-cock leading to the gas bag is open. Otherwise the tube will be blown off the cylinder or will burst.

6. Always keep the aperture *A* closed.

Nitrous oxide may be administered:

1. Pure, as in dentistry.

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* New edition of "Reference Handbook of Medical Sciences," vol. iii., p. 10.

2. With air or oxygen, as in the longer operations of surgery.

In a simple administration of gas with the Bennett inhaler, the technique is as follows:* "The tap being fully opened, the bag is filled with gas from the cylinder through the rubber tube supplied with the inhaler. Aperture *D* should be fully opened. The rubber rim of the face-piece should be moderately inflated. The face-piece should be applied so perfectly that the valves act well, the inspired air entering at *E* and the expirations escaping at *D*. Upon closing the tap *E*, gas will be drawn from the bag on inspiration, escaping at *D* on expiration. As soon as the inhalation begins, a flow of gas sufficient to keep the bag moderately full should be turned on from the cylinder." The patient will now be inspiring gas through the inspiratory valve, and expiring gas plus air through the expiratory valve into the air, so that an increased amount of gas is constantly entering and more air constantly leaving the lungs, provided the face piece is so perfectly applied as to exclude all atmospheric air.

At the end of from fifty seconds to two minutes, varying with the patient and the anæsthetist, *signs of gas anæsthesia*, complicated with those due to limitation of air, will appear. These are:

1. Rapid deep and stertorous respiration..	Signs of gas anæsthesia.
2. Rapid pulse	
3. Dilated pupil	
4. More or less cyanosis	Due to anoxæmia.
5. Jactitation	
6. Clonic movements of the extremities	

If too little gas has been given, all these signs will be less marked, and excitement, with struggling and mild delirium, may occur, whence the term "laughing-gas."

If too much gas and too little air has been given, the breathing will become very rapid, jerky, and loudly stertorous; cyanosis would become intense; pulse very rapid and of poor quality; and, if the administration were continued without air, the respiration would cease, the pulse continuing to beat.

In a simple gas administration, when signs of anæsthesia appear, the face-piece should be removed and the operation begun, or ether should be substituted according to the purpose of the administration. The period after the withdrawal of the face-piece, during which operative procedures may be continued, is known as that of available anæsthesia, and varies, according to Hewitt, from fifteen to forty-five seconds.

Should signs of asphyxia—*i.e.*, cyanosis and jactitation—develop too early the ymay be delayed, and the period of available anæsthesia usually prolonged, by closing aperture *D*, thus throwing the valves out of action and allowing the patient to breathe to and fro into the bag a mixture of gas plus the residual air in the lungs.

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* Directions from circular that accompanies inhaler, slightly modified.

The accidents which may occur with nitrous oxide are usually entirely respiratory, the heart continuing to beat after respiration is arrested. The treatment for this condition is to open the mouth, draw forward the tongue, and, if necessary, perform artificial respiration.

Patients usually recover consciousness from gas in from twenty to fifty seconds. The return to consciousness is abrupt and they are at once clear-headed and normal. There is rarely any nausea or vomiting. Slight headache and dizziness are not uncommon. Temporary glycosuria has been known to follow the administration of nitrous oxide. As a rule, however, nitrous oxide is followed by no post-anæsthetic sickness.

Nitrous Oxide and Air; Nitrous Oxide and Oxygen.

The continuous administration of gas with varying amounts of air or oxygen has lately been practised by English and American anæsthetists, who have recorded administrations lasting from half an hour to two hours in major surgical operations.

In certain selected cases a skilful anæsthetist can, especially with gas and oxygen, produce a perfectly non-asphyxial form of anæsthesia without cyanosis, jactitation, or clonic movement, and with a certain amount of muscular relaxation.

The disadvantages of this method are its danger when used in long operations, the high degree of skill required to produce satisfactory anæsthesia, the complicated and cumbersome apparatus, the large quantity of the gases used, and the very rapid recovery of consciousness with consequent post-operative pain. The form of anæsthesia which is thus produced is so essentially light that certain patients, such as athletes, alcoholics, plethoric and obese people, cannot be properly controlled; and, in fact, muscular relaxation is difficult to produce even in the most favorable subjects.

The advantages are the rapid recovery and absence of post-anæsthetic sickness, irritation of the lungs or kidneys, and strain on the heart and circulation.

It is useful, therefore, in certain forms of pulmonary, cardiac, and renal disease and in cases which have had severe post-anæsthetic sickness following the administration of ether or chloroform.

It should never be undertaken by any but a thoroughly skilled anæsthetist.

Gas and Air.

For the administration of gas and air a Bennett gas inhaler may be used. Anæsthesia is induced as described for a simple gas administration, but, instead of removing the inhaler when anæsthesia is complete, the administration is continued, an effort being made to admit enough air to dispel asphyxial symptoms. Air is admitted either continuously by keeping aperture *A* slightly open, or intermittently by widely opening aperture *E* for one or two inspirations when cyanosis or other signs of anoxæmia begin to appear. It is obviously difficult to admit enough air to avoid signs of asphyxia and at the same time keep the patient properly controlled by nitrous oxide. Still, in favorable subjects, such as ischæmic middle-aged women or men, a tolerable form of anæsthesia may be produced, although muscular relaxation usually does not occur.

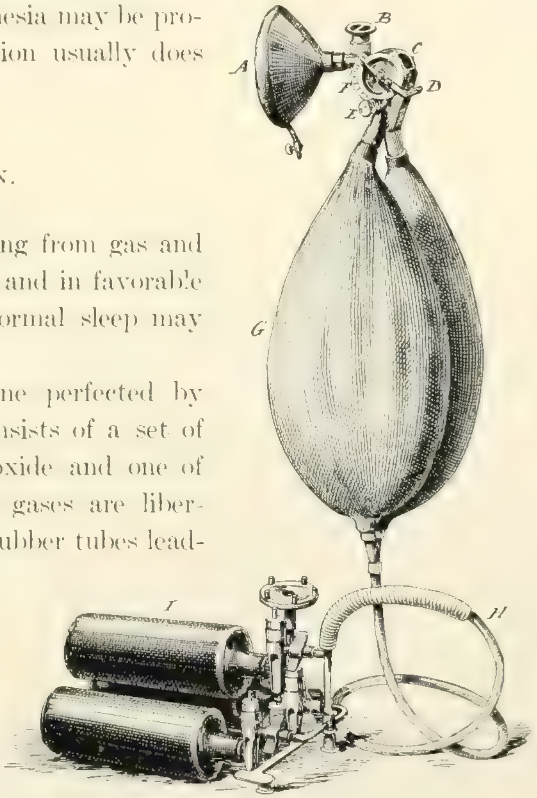

Fig. 72.—Hewitt's Nitrous Oxide and Oxygen Apparatus. (Thomas L. Bennett, in "Reference Handbook of the Medical Sciences.") *A*, Face-piece with inflatable edge; *B*, expiratory valve; *C*, air-tap for inspiration when the gas is cut off; *D*, lever by which gas and oxygen are turned on; *E*, special stop-cock for turning on more oxygen than is controlled by lever *D*; *F*, index showing proportion of oxygen from 1 to 10; *G*, double bag, one side for gas, the other for oxygen; *H*, double tube (one within the other); *I*, cylinders of gas and oxygen.

Gas and Oxygen.

The form of anæsthesia resulting from gas and oxygen is much more satisfactory, and in favorable subjects a condition resembling normal sleep may be produced.

The apparatus used is the one perfected by Hewitt in 1894 (Fig. 72). It consists of a set of three cylinders—two of nitrous oxide and one of oxygen. From the cylinders the gases are liberated by foot keys into separate rubber tubes leading to separate partitions of a large rubber bag—one partition for oxygen, the other for nitrous oxide. From its partition the oxygen passes (1) to an oxygen chamber, whence by the regulating stop-cock it is admitted (2) in definite amounts to the mixing chamber, where it mingles (3) with the nitrous oxide which has passed from its partition of the bag directly to the mixing chamber. From here it passes (4) into the face-piece and is breathed by the patient.

In an administration with this apparatus the procedure is as follows:

Enough of the two gases to fill each half of the bag about two-thirds full is turned on. A more or less constant stream of nitrous oxide will be necessary, but an occasional turn of the oxygen key will keep the oxygen side of the bag two-thirds full.

With the indicator pointing to "Air" the face-piece is accurately applied and the patient breathes air through valves which should be heard to work with a sharp click. The indicator is then turned to "N_2O" and afterward to "O_2." "O_2" means that approximately two per cent of oxygen is mixing with the nitrous oxide in the mixing chamber, the oxygen entering the mixing chamber from the oxygen chamber through a series of ten small apertures, two of which are now opened by the regulating stop-cock.

In two or three minutes complete anæsthesia will result. The signs of this are:

Rhythmical, softly stertorous breathing;

Dilated pupil with loss of conjunctival reflex;

Fixed eyeballs;

More or less muscular relaxation.

If too little oxygen is given, cyanosis, jerky and loudly stertorous respiration, and clonic movements of the extremities will result.

If too much oxygen is given, signs of excitement, movements of the extremities, phonation, or active delirium may occur, with other signs of recovery from the anæsthesia.

More oxygen may be admitted by moving the indicator to 3, 4, 5, etc., up to 10″, when, by a supplementary stop-cock, an additional ten or twenty per cent of air may be admitted.

During the administration enough oxygen should be given to do away with cyanosis, etc., but not enough to counteract the anæsthetic effect of the nitrous oxide.

A favorable subject, under gas and oxygen anæsthesia, should show a normal or slightly heightened color, soft or slightly snoring breathing, and muscular relaxation. It is difficult for any but an expert to maintain an even anæsthesia, owing to the rapid changes that follow too much or too little of either gas or oxygen. Any jolting or moving of the patient when anæsthetized will markedly disturb the administration. The administration should be started, therefore, not only on the operating table, but in the position—lithotomy or Sims, for example—in which the operation is to be performed.

Recovery is usually rapid, patients recovering complete and normal consciousness in from one and a half to two minutes. There is usually no post-anæsthetic sickness, although nausea and vomiting occur more frequently than after gas and air, probably owing to the mucus and saliva sometimes produced.

On the average, one hundred and fifty gallons of nitrous oxide and fifty gallons of oxygen per hour would be used, so that the cost of anæsthesia by gas and air or gas and oxygen is considerable.

ETHER.

Ether is a very volatile and inflammable liquid, with a pungent odor, a burning taste, a low boiling-point (95° F.), and a specific gravity of .720.

For anæsthesia the purest ether obtainable should be used. It is sold in hermetically sealed tin cans and it is best to purchase the small sizes containing 100 gm. or 250 gm. These should be opened only as required, should be kept tightly corked and away from heat or sunlight. Ether should not be opened within ten feet of an open flame, and, when the cautery is in use at an operation, the ether inhaler should be covered with a wet towel.

Ether is a powerful cardiac and respiratory stimulant. When inhaled its fumes are irritating to the mucous membrane of the respiratory passages, causing coughing, secretion of mucus, and more or less hyperæmia with consequent swelling of the mucous membrane. Ether accelerates the heart's action and causes a rise of blood pressure. Prolonged etherization diminishes the amount of hæmoglobin in the blood and also lowers the body temperature. During the early stages of etherization the respiration is rapid, deep, and stertorous; the whole circulation is stimulated, and there is often seen on the neck and chest a mottled appearance due to capillary turgescence and known as "ether rash." This is physiological and disappears as anæsthesia deepens. Sweating is common during ether anæsthesia. Ether is irritating if allowed to evaporate rapidly upon the skin, causing destruction of the epidermis, the lesions being known as "ether burns." During the lighter degrees of ether anæsthesia a general tremor of the body, known as an "ether chill," may be observed. It is without special significance.

Prolonged inhalation of ether causes irritation of the kidneys, as shown by post-operative albumin in the urine.

When administered by rectum, ether seems in some cases to cause bloody diarrhœa and serious collapse.

In ether accidents the heart usually continues to beat after the respiration has ceased.

Owing to its stimulating effect upon the heart and respiratory centre, ether is a safe anæsthetic. Except in diseases like diabetes, Bright's disease, uncompensated heart disease, certain lung diseases, empyema, etc., ether, even in unskilled hands, is not especially dangerous. Statistically, Hewitt places its death-rate as one in sixteen thousand, making it less safe than nitrous oxide, five times safer than chloroform, safer than mixtures of chloroform and ether, and safer than ethyl chloride or somnoforme.

Owing to its low boiling-point and volatility, ether is rapidly eliminated from the lungs and is therefore usually administered with more or less limitation of air.

Owing to the fact that the fumes of ether are considered very disagreeable to inhale by most patients, it is rare, except in a country practice, that ether is employed for the induction of anæsthesia. Usually gas, chloroform, ethyl chloride, or some more pleasant-smelling agent is used until the patient becomes unconscious, and then ether is substituted.

Methods of Administering Ether.—Ether may be administered by:

1. The *open* method;

2. The *semi-open* method;

3. The *close* method (these three methods being thus designated according to the amount of air limitation practised); and

4. By rectum.

1. *The Open Method.*—In the open method ether is poured drop by drop on a towel, folded gauze, or chloroform mask, with no attempt at air limitation. Any form of drop-bottle may be used, or a gauze wick two or three inches long may be inserted along the cork of an ordinary ether can, this contrivance making a good dropper. Ether must be dropped slowly at first, after two or

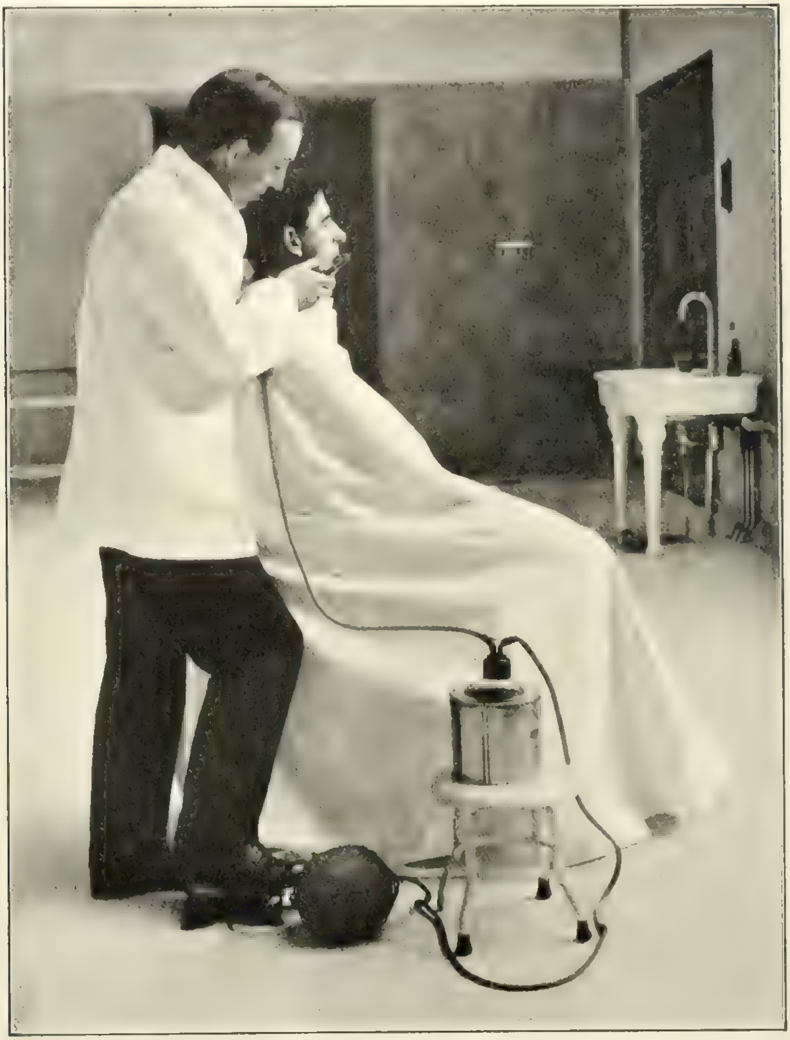

Fig. 73.—Greene's Thermo-ether Inhaler.

three minutes more rapidly, and, when the stage of excitement or struggling is reached—say, in from five to six minutes,—a free dropping should be kept up. When anæsthesia is complete, *i.e.*, in from six to ten minutes, a steady dropping of, say, thirty to fifty drops a minute may be kept up for five minutes, and then just enough should be given properly to control the patient.

This method is applicable chiefly to children and feeble subjects. It may fail to control strong and full-blooded patients. The constant dropping tends to produce an even anæsthesia, and the free air-supply prevents cyanosis.

The disadvantages of the method are: That, owing to the extreme volatility of ether, most patients cannot be properly controlled even when enormous quantities are used; that the large amount of ether necessary fills the room with its fumes; that much ether is wasted; and, finally, that the recovery of the patient is not apt to be so satisfactory and so free from post-anæsthetic sickness as it would be after a skilful administration by the close method.

The administration of ether by Greene's thermo-ether inhaler* (Fig. 73) may be called a form of the open method, inasmuch as no air limitation is attempted. It is useful in prolonged operations about the nose and mouth, or in any operation about the head where the surgeon requires to work without interruption by the frequent removal and reapplication of an inhaler. The apparatus consists of a glass ether bottle (1) holding about one pint, which is placed in a brass double cylinder (2) containing water. The water in the inner cylinder and surrounding the ether bottle is heated to 110° F., that in the outer cylinder to 150° F. (65.5° C.). In this manner the ether is vaporized rapidly and its strength increased. A rubber tube is attached to a small foot pump (3) and is led through the stopper of the ether bottle to within one inch of the bottom (*i.e.*, is immersed in ether). At about its middle this afferent tube is expanded into a dilatable rubber bag (4), which is kept distended by the foot pump in order to maintain constant air pressure. Another tube (5) leads from the ether bottle to the patient and ends in a bent hard-rubber mouth-tube with an automatically closing stop-cock (6). Air from the foot pump distends the rubber bag, which in turn forces it through the ether in the bottle. There it mixes with ether vapor and is carried to the patient's mouth by the efferent tube. The stop-cock allows ether vapor to be breathed only during inspiration. Before the apparatus is used, the patient should be deeply anæsthetized by ordinary methods; otherwise the strong vapor from the thermo-inhaler will cause reflex coughing. Once well started, however, profound anæsthesia can be maintained and prolonged operations done without interruption.

2. *The Semi-Open Method.*—In this method one of the various forms of semi-open inhalers is used. These limit the air supply more than is the case in the open method, though not so much as in the closed method.

Rendle's mask (English) and Allis' inhaler (American) are well-known forms of a semi-open inhaler. An ordinary ether cone properly made of towel, gauze, and pasteboard is an excellent form of semi-open inhaler, being clean, pliable, and close-fitting (Figs. 74 and 75).

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* Boston Med. and Surg. Jour., vol. cxlviii., No. 18, pp. 470 and 471, April 30th, 1903.

Actual Administration of the Semi-open Method.—As far as any one method may be said to be, the administration of ether by the semi-open method is the most generally useful as well as the safest and most practical method of anæsthetizing. When general practitioners or persons unskilled in the use of anæsthetics are called upon to give ether this will usually be the method employed. A detailed description of such an administration will therefore be given. Obviously, certain of these details apply also to the administration of other anæsthetics, notably of chloroform and its mixtures.

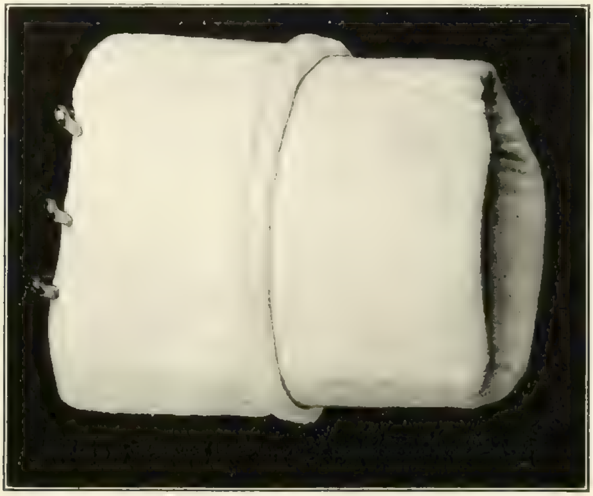

Fig. 74.—Massachusetts General Hospital Ether Cone.

Humanely to induce complete anæsthesia by ether it is well to allow ten minutes for most cases.

Having secured absolute quiet in the room, and avoiding all appearance of hurry and confusion, pour a small dose of ether directly upon the gauze at the top of the cone, and hold it six or eight inches from the patient's face, encouraging him to breathe freely and naturally through the mouth or nose or both. The patient should not be told to take deep breaths at first, as this will provoke coughing, the secretion of mucus, and salivation. As the patient becomes more accustomed to the vapor, the inhaler should be moved nearer the face, ether being added frequently in small doses but not allowed to wet the edges of the inhaler where it comes in contact with the face, as this might cause "ether burns."

At the end of from four to six minutes, if the administration has been steadily continued, excitement, struggling, or delirium will occur. This is known as the "stage of excitement." It may be possible, if the patient be not restrained in any way, to avoid struggling by carefully and steadily increasing the strength of the vapor, which should still be well diluted with air. If, however, the patient be held, he may misinterpret this as the signal for violence and resist. If it seems impossible to avoid resistance the patient should be properly restrained, to do which requires three persons, as a rule. The anaesthetist with his elbows on the table holds the patient's head between his forearms, controlling the inhaler with his hands; one attendant controls the arms by grasping the wrists; another the legs by holding down the knees.

A large dose of ether should now be given and more air-limitation practised until the patient is forced into complete anæsthesia, the signs of which are regular and stertorous breathing, muscular relaxation, moderately dilated pupil, and absent conjunctival reflex.

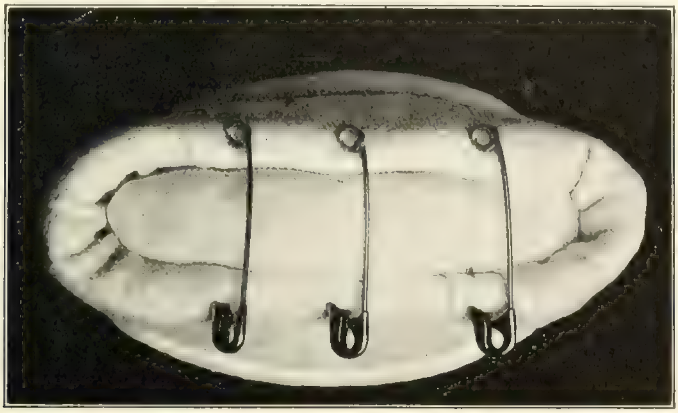

Fig. 75.—Massachusetts General Hospital Ether Cone; top view. Semi-open method.

A flat pillow is well suited for the support of the patient's head, which should now be turned to one side and kept in this position throughout the anæsthesia and during the recovery period until the return of the coughing and the swallowing reflex. This is important, because with the head in this position respiration is more efficiently performed, the tongue tending to fall forward and away from the pharynx, and the danger of inhaling mucus, saliva, and vomitus being avoided by the free escape which this position of the head affords. The head should be neither hyperextended nor flexed.

To produce good breathing it may or may not be necessary to hold forward the jaw. If breathing is good, *i.e.*, if inspiration and expiration are ample and if obstructive stertor is absent, no jaw-holding is necessary. But if the breathing is poor, the jaw may be held forward either from behind or by a finger on the point of the jaw, thus pulling the base of the tongue away from the pharyngeal wall. If undue force be exercised in pressing the jaw forward, pain and a sense of lameness will be caused by the act at the seat of pressure.

The patient's shoulders should be depressed to straighten the neck, and the elbows should be allowed to rest on the table to favor free expansion of the chest.

When the anæsthesia is once complete it should be maintained by frequently adding small doses of ether rather than by pouring on large ones when the patient shows signs of recovery. The signs of recovery, or of the patient's becoming "light" (lightly anæsthetized), are: The breathing becomes slower, irregular, and less audible, and there is occasional sighing; the corneal, conjunctival, and pupillary reflexes become active, and lachrymation occurs; the swallowing reflex returns and will be followed by retching, which is likely to go on to vomiting.

If the operation does not require profound anæsthesia and complete muscular relaxation, an effort should be made to keep the patient "lightly under," *i.e.*, with tranquil, noiseless breathing and active eye reflexes. As far as any specific directions can be given for doing this, they are: Keep the inhaler closely applied to the face, and add small doses of ether at frequent intervals.

When, however, deep anæsthesia is required, as in laparotomies, care should be taken not to over-etherize the patient. The signs of over-etherization are:

Respiration becomes gasping, with short inspiration and prolonged expiration; the pupil is widely dilated and does not react to light; the corneal and conjunctival reflexes are absent; the general appearance is bad, with pallor or marked cyanosis; the pulse is rapid and thready.

In estimating the profoundness of the anæsthesia the respiration is the most important guide. It varies with the amount of the anæsthetic administered and also undergoes reflex changes due to the operative procedure. For example, the respirations, being tranquil and inaudible, may become rapid, deep, and stertorous as soon as operative procedures are begun. This is "reflex breathing" and should be considered in judging the sound of respiration. In general, the greater the amount of anæsthetic administered the more rapid the rate and the greater the depth and stertor of the respiration.

The pupil is of some importance in estimating the depth of the anæsthesia. A dilated pupil that does not react to light usually indicates deep anæsthesia, but the pupil may also be dilated and fixed in light anæsthesia. In this latter case it is due to the reflex effect of the operation and would contract with the addition of more ether, besides being associated probably with an active corneal and conjunctival reflex. In the first instance, however, the corneal and conjunctival reflexes would be absent, and the addition of more ether would still further dilate the pupil.

As anæsthesia deepens, the conjunctival reflex first disappears and then the corneal reflex.

The eye, however, should not be relied upon too much, and the above reflexes should always be considered in conjunction with the breathing, the general appearance, the pulse, etc., in estimating the patient's condition.

The conjunctival and corneal reflexes should be tested seldom, and then as lightly and carefully as possible, in order not to infect the conjunctiva and not to brush off the corneal epithelium. After testing them the upper lid should be held closed for a moment to wash away any possible infection.

The pulse during etherization should not take the anæsthetist's attention from the respiration. It may be taken at the temporal, the facial, or the radial artery, and counted by the quarter or half minute, and reported if unduly rapid or of poor quality. If shock or hemorrhage occurs, however, careful watch of the pulse must be kept. It is well to have a capable attendant do this, in order that the anæsthetist may give his whole attention to the breathing and to the administration of the anæsthetic.

Vomiting occurring during anæsthesia will usually be preceded by the above-mentioned signs of recovery. By the addition of more ether an effort should be made gradually to abolish this reflex, but if it fails the head, if otherwise placed, should be turned to one side, the mouth and throat sponged out, and, during the first pause in the emesis, fresh ether should be added on a clean inhaler if the first has been soiled.

The presence of mucus in increased amount during etherization may interfere with respiration, although this seldom happens if atropine, or morphine combined with atropine, has been given. The treatment is to turn the head to one side, to press the jaw forward, and to place a gauze drain in the lower cheek to provide free drainage for the mucus. The throat may be sponged out, although this seldom does any permanent good. In extreme cases it may be necessary to stop etherization, turn over the patient to cause escape of the mucus, and then resume the administration with chloroform or a mixture containing this drug.

As the operation progresses, less and less ether should be used, the anæsthesia being so graded that when the last stitch is taken the patient will be showing signs of recovery. The administration should not be stopped so early that retching and vomiting will annoy the surgeon, but it should be unnecessary to leave the patient snoring in profound anæsthesia when the operation is finished.

The Close Method.—The administration of ether by the close method was introduced by Mr. Clover, a London anæsthetist, in 1876. In it an extreme degree of air-limitation is practised, just enough air being allowed to keep the blood oxygenated and the facial color good. The inhalers used are fitted with rubber bags which act as reservoirs for ether vapor and from which this vapor is breathed, air being admitted continuously or intermittently to mingle with the ether vapor.

Familiar types of closed inhalers are Clover's or Ormsby's (English) and

Bennett's (American) (Fig. 76). The latter being taken as a type, the following is the technique of an administration by this method:

Bennett's ether inhaler consists briefly of—

1. The metal face-piece, with aperture *A* for the admission of air, and an inflatable rubber rim for the exclusion of air.

2. The ether chamber containing a wire cage, which is packed with gauze to be saturated with ether. Running through the cage is an air-shaft. When the index on the outside of the ether chamber is at "Air" the ether is shut off and air is breathed through the air-shaft.

3. The bag fitting upon the ether chamber and having an air-tap, *C*.

The technique of the administration follows in the words of the circular that accompanies each inhaler:

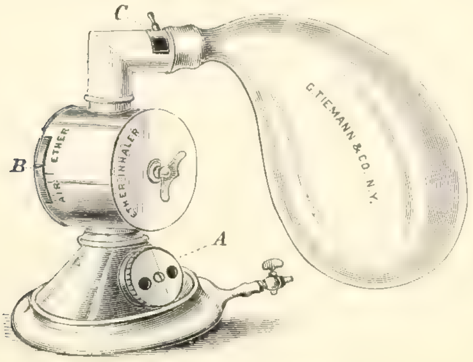

FIG. 76.—Ether Inhaler.

Ether Inhaler.—Take the ether chamber apart by removing the thumb-screw. Pack the wire cage (*in situ*) firmly with dry gauze. It will hold a piece one yard wide and ten or twelve inches long. Do not allow the ends of the gauze to interfere with the mechanism of the inhaler. Turn the index to the upward limit (full ether) and pour from one-half to one ounce of ether upon the gauze—one-half through the face-piece, the other half through the chimney at the top of the ether chamber. Now turn the index to the downward limit (full air) and attach the bag. The rubber cushion of the face-piece should be moderately inflated. The air traps at *A* and at *C* should be closed. Apply the face-piece during several expirations, so as to distend the bag moderately; then keep the inhaler applied and turn the index at once to the line between *air* and *ether*. Now turn the index toward *ether*, about one-sixteenth inch, every two or three inspirations, or as slowly as necessary to avoid the effects of too strong ether fumes. In about one minute the index will have been moved forward one-fourth or one-third the distance between the *line* above referred to and the *upward limit*. Occasional inspirations of air should now be given by removing the inhaler from the face, and the index should be moved more gradually forward until complete anæsthesia is present. This is accomplished in from two to five minutes in average patients. When the index has reached a little more than one-half the distance from the *line* to the *upward limit*, full ether is on and the index should be at once moved to the *upward limit*. The administration consists chiefly in the regulation of two factors: 1. The air supply; and, 2, the ether supply.

1. *The Air Supply.*—During the induction of anæsthesia the air supply should be limited as above; enough should be given, however, to prevent more than slight cyanosis. Patients differ greatly in the amount of air they require with ether, and the air supply must be regulated in accordance with the following facts: The tap *C* being closed, if *A* is opened slightly the patient will receive little air and much

ether; if fully opened he will receive much air and little ether. The tap *A* being closed, if *C* is opened slightly, the patient will receive little air and much ether; if fully opened, he will receive much air and much ether.

2. *The Ether Supply.*—At the beginning, the ether chamber should be charged, as above, with from one-half to one ounce of ether, according to the patient, and this will usually be sufficient to induce complete anæsthesia. It is best to continue the administration with the index turned to the *upward limit*, and from one-half to one drachm of ether every two or three minutes will be found enough for the average patient. Ether may be added, (1) through the face-piece, (2) through the chimney, or (3) through the revolving disc on the side of the ether chamber. (1) is preferable in usual cases, (2) or (3) is of great advantage when it is inconvenient to remove the inhaler from the face.

The quantity of ether necessary will average four ounces for the first hour and two ounces for the second hour.

The disadvantages of this method are: Special skill is required; an uneven anæsthesia, with rapid, loudly stertorous breathing and cyanosis, results when the administration is in unskilled hands; the apparatus requires care and should be cleaned or sterilized for each administration.

Plethoric or alcoholic patients are difficult to control by this method.

The advantages are: The great reduction in the amount of ether necessary results in a prompt recovery with less post-anæsthetic sickness than when other methods are employed; the more rapid induction of anæsthesia than with other methods; the ether vapor, inhaled from the bag, being warm, is less irritating to the respiratory mucous membrane and thus is less likely to be followed by bronchitis.

Rectal Etherization.—The administration of ether by the rectum was tried by Pirogoff and Roux in Russia in 1847. In 1884 Mollière and Yversen in France, Post and Gay of Boston, and Weir and Bull of New York reported series of cases. Dr. Dudley Buxton, of London, has had a considerable experience with it. So far as may be judged from the writings of these observers, from the principal text-books on anæsthetics, and from the experiences and observation of the present writers, the method seems to be by no means without danger. Bloody diarrhœa with collapse and death has been known to follow its use. On the other hand, Cunningham, of Boston, in 1905, reported a series of forty-one cases without deaths or untoward symptoms, and he is still using the method.

The writers believe, however, that it entails distinct risk, and that it should be avoided except in certain special cases in which other methods fail to produce an anæsthesia under which the operation can be successfully performed. Such cases, for example, as extirpation of the tongue or larynx for cancer, cases of empyema or of unresolved pneumonia requiring operation, might warrant its use.

Its chief advantage is that it gives the surgeon an absolutely free field for operating on the mouth, nose, and throat.

The rectum should be thoroughly clean and empty at the time of administration. This is accomplished as described under "Preparation" (p. 173), except that a large cleansing enema should be given in the morning and another one-half an hour before operation.

A good apparatus to use for the introduction of the anaesthetic is the Greene thermo-ether inhaler (Fig. 73), a cautery bulb being substituted for the foot bellows and a rectal tube for the patent stop-cock. (Fig. 77.)

The bottle should be a graduated one and should contain about eight ounces of pure ether. The temperature of the water should not exceed 100° F. Air is forced through the ether by the cautery bulb attached to the afferent tube, and, becoming laden with ether vapor, leaves the bottle by the efferent tube, which terminates in an ordinary rectal tube. Between the efferent tube and the rectal tube is a glass interceptor which prevents liquid ether from entering the rectum.

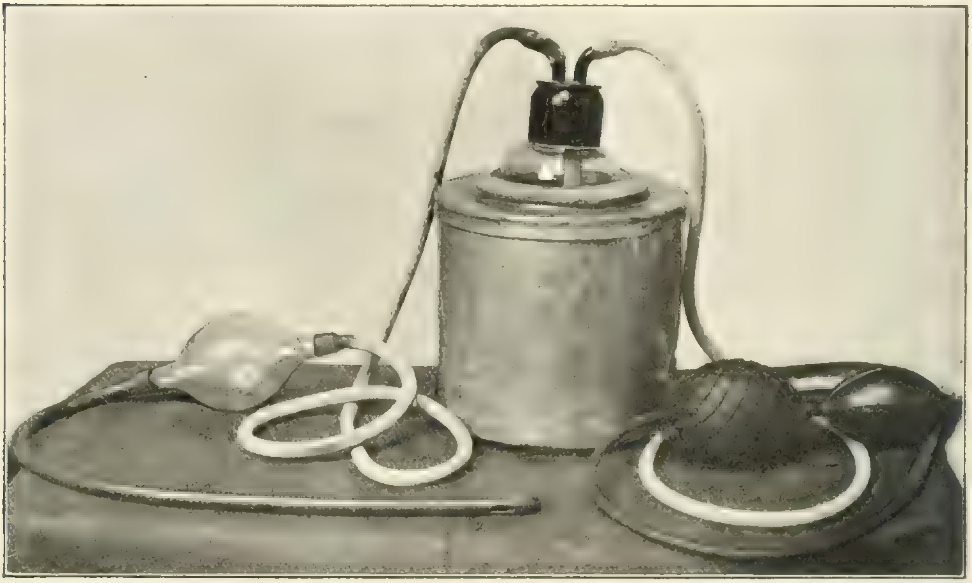

Fig. 77.—Apparatus for Administering Ether by the Rectum.

With the patient in the dorsal posture one thigh is held slightly elevated by a sand bag. The rectal tube is then introduced a distance of eight or ten inches, and any flatus that may be present aided to escape. The interceptor, with the rest of the apparatus, is attached to the rectal tube and one or two gentle pressures of the bulb are made. As the rectum becomes distended, the forefinger held inside the sphincter, along the rectal tube, allows ether vapor plus air to escape from the rectum. Gentle pressures of the bulb should now be made at regular intervals, and as the patient becomes accustomed to the tube the finger may be withdrawn. As the bowel absorbs the vapor the patient may complain of a desire to defecate or of slight abdominal pain. This is due to distention and must be met by reintroducing the finger to allow the escape of superfluous vapor. In from three to five minutes the odor of ether may be perceived in the patient's breath. In two or three minutes more he becomes drowsy, the eyes close, the breathing becomes tranquil, regular, and slightly stertorous, and he passes into complete anæsthesia, usually without excitement or struggling. The time necessary to produce complete anæsthesia varies from six to fifteen minutes according to the patient, and probably also according to the condition of the rectal mucous membrane. Anæsthesia, once established, is easily maintained by gentle pressures of the bulb every few minutes according to the patient's manifestations. After the operation the rectal tube is disconnected but left *in situ*, while gentle massage along the course of the colon expels any remaining ether vapor.

This method consumes very little ether, from four to six ounces an hour usually being sufficient.

As a rule, post-anæsthetic sickness does not occur, although slight nausea and vomiting may follow.

As above stated, however, in certain cases the patients have abdominal pain, tenesmus, bloody diarrhœa, and collapse. Several deaths have occurred following the use of this method.

These intestinal symptoms are best treated by enemata of starch and opium, aided by opium hypodermically if necessary.

Emergencies and Accidents Occurring during Etherization.—Emergencies and accidents occurring during etherization have to do usually with failure of respiration, the heart, as a rule, continuing to beat after respiration has ceased. For this reason ether accidents are not so dangerous as those from chloroform, and patients can usually be saved.

The treatment of an excess of mucus or of vomiting occurring during etherization has already been given.

Vomiting and the subsequent inhalation of solid food, on the part of anæsthetized patients, constitute an awkward accident. In these cases, which occur now and then, the treatment is to open the patient's mouth, draw forward the tongue, try to remove the obstruction with the finger or with forceps, invert the patient, pound the back, and finally perform rapid tracheotomy if the first measures fail.

In general, the treatment of all accidents occurring during anæsthesia is the same. It consists of establishing a free way for the entrance of air by opening the mouth and drawing forward the tongue, and of re-establishing respiration by Sylvester's method. If the failure of respiration occurs during the deeper degrees of anæsthesia, there is no difficulty in opening the mouth: but if it occurs in the lighter stages, the teeth may be firmly clenched and may require to be pried open. This should be done with the wooden wedge (1, Fig.

69), and a rubber bite-block or spring gag should be inserted to hold open the mouth while the tongue is drawn forward.

ARTIFICAL RESPIRATION.—If the measures described above do not re-establish breathing, one should begin artificial respiration (Figs. 78 and 79). With the patient fully extended on the table, the head a little to one side, and the neck straight, firmly press the sides of the thorax with the patient's arms, which should be grasped just above the elbows. This imitates expiration (Fig. 78), tends to remove part of the anæsthetic from the lungs, and will often initiate breathing.

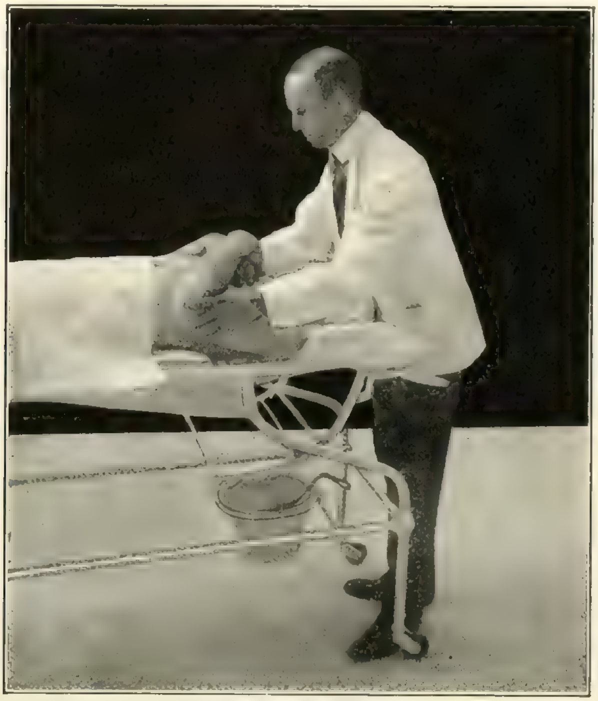

FIG. 78.—Artificial Respiration. (Expiration.)

Shifting the grip to the wrists, the anæsthetist should now slowly raise the patient's arms above the head and should fully extend them in this position (Fig. 79), in imitation of inspiration. They are then again lowered to the sides, and the thorax firmly compressed as before. These movements should be made deliberately, and the rate should not exceed fifteen or sixteen full respiratory movements a minute. If necessary, traction may be made on the tongue synchronously with the movements of the chest, the tongue being drawn slightly forward during inspiration and released during expiration. Artificial respiration should be persisted in for at least half an hour, as patients have often been saved after even longer periods. It may be supplemented by allowing a light stream of oxygen to escape over the region of the nose and mouth, by holding spirits of ammonia on gauze before the nostrils, or by dashing a few drops of ether upon the bare chest. The proper performance of artificial respiration is, however, our principal resource in all anaesthetic accidents, and should not be neglected for fruitless hypodermic stimulation, feeling of the pulse, etc.

CHLOROFORM.

Chloroform is a heavy, colorless, non-inflammable liquid, with a sweetish, burning taste and a characteristic odor, a boiling-point of 61° C., and a specific gravity of 1.491 at 17° C. When exposed to light and air, chloroform undergoes decomposition and is rendered unfit for use. It should, therefore, be purchased in small dark bottles containing 100 grammes and kept tightly corked in a cool dark place.

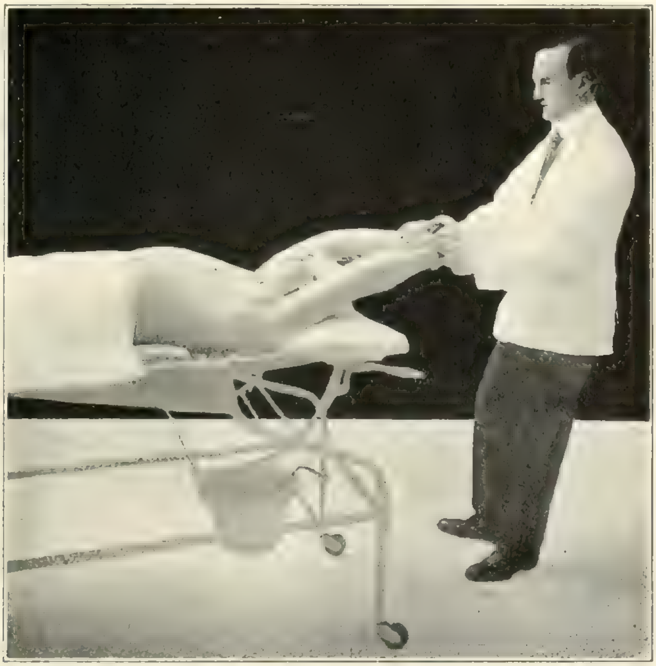

FIG. 79.—Artificial Respiration. (Inspiration.)

When used in a room with an open flame the vapor undergoes decomposition with liberation of hydrochloric acid and fumes which are irritating to the respiratory mucous membrane. Before using, chloroform may be warmed by placing the bottle in water at 100° C. (212° F.), thus making it vaporize more readily. The dangers of chloroform are lessened by using oxygen during its administration.

Upon the respiratory centre chloroform has first a stimulant and then a depressant action. It has a marked tendency to cause irregularities of the respiration, which react upon the circulation.

It is a direct cardiac depressant and produces a vaso-dilator action upon the media of the blood-vessels and upon the heart muscle. It lowers blood pressure. For these reasons it is a comparatively dangerous anæsthetic. Hewitt estimates its death-rate as one in three thousand, making it five times less safe than ether.

In England and in certain parts of the Western and Southern United States chloroform is in common use, with a corresponding number of deaths and accidents. In the hands of an experienced anæsthetist, and when used after ether or with oxygen, it is reasonably safe, but in any community in which it is used by inexperienced persons accidents and deaths are apparently not infrequent. These instances are not always reported and probably are often not recognized as due to the anæsthetic.

Chloroform is safer when used to maintain an anæsthesia begun with ether or with gas and ether, than when used from the beginning: ether supporting the heart and respiration against the depressing action of chloroform. Statistics show that a large percentage of deaths under chloroform occur during the first part of anæsthesia, notably during the stage of excitement, when patients in struggling may clench the teeth and hold the breath. This imprisons in the lungs the chloroform already administered, and if the drug be not dropped slowly and cautiously the patient may inhale an overdose when breathing is resumed. Then, again, with inexperienced givers the drug may be thoughtlessly pushed to overcome the struggles of the patient, or during the excitement an unexpected amount may be inhaled by the patient.

Chloroform has a slightly vesicant action on the epidermis and it is wise to smear the nose, cheeks, and lips with lanolin before beginning the administration.

Post-anæsthetic sickness from chloroform is often entirely absent, but when it does occur it is much worse than that produced by ether. Uncontrollable vomiting sometimes results and may be serious.

Chloroform is irritating to the kidneys, although less so than ether.

It is less irritating to the respiratory mucous membranes than ether and is much more agreeable to inhale.

The inhalation of chloroform lowers the body temperature.

Administration of Chloroform.—Chloroform should be administered by the open method, drop by drop, and with a liberal supply of air. A piece of folded gauze, the corner of a towel, and (preferably) a Skinner's, an Esmarch (Figs. 80 and 81), or a Schimmelbusch mask (Fig. 82), covered with several layers of gauze or a single layer of Canton flannel, are the commonest forms of inhalers used, and with them should be employed one of the numerous forms of drop bottles, fitted with a stopper by which the flow of the drug can be accurately controlled.

For tracheal chloroforming, and for the use of chloroform in operations about the nose and throat, as well as for ordinary administrations, many forms of regulating chloroform inhalers have been devised. A good one is Krohne's modification of Junker's inhaler (Fig. 83). With this apparatus, pressure upon a bulb forces air by an efferent tube through chloroform contained in a graduated bottle. The chloroform vapor thus generated leaves the bottle by an efferent tube terminating in a face-piece or a bent silver tube. At the top of the face-piece is a broad feather on a delicate hinge. The feather, which moves with respiration, forms an index of its rate. The bulb is divided into three sections of different sizes. A full compression of the smallest bulb delivers into the face-piece 10 c.c. of air laden with chloroform vapor: of the middle bulb, 30 c.c.; of the largest bulb, 60 c.c. The bulb is to be compressed at the finish of expiration or the beginning of inspiration. The inventor claims that it is impossible to give an overdose by this inhaler. It is a very useful and practical apparatus for chloroforming children, and for tracheal and intraoral chloroforming, the bent silver tube being used for the latter. It consumes very little of the drug and regulates the dosage satisfactorily.

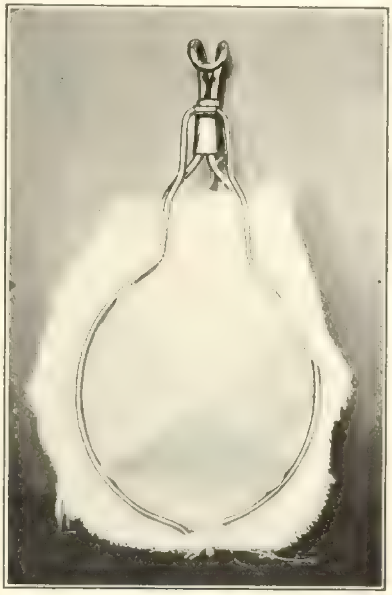

Fig. 80.—Esmarch Mask. Open method of administering chloroform.

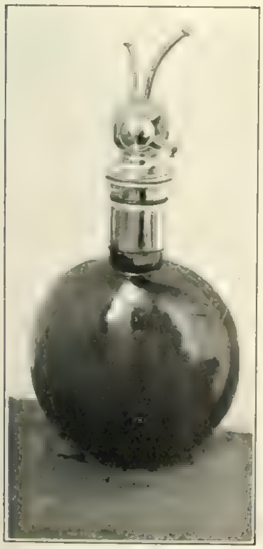

Fig. 81.—Esmarch's Drop Bottle. Open method of administering chloroform.

Unfortunately, the varying depth of the respirations has so much to do with determining the amount of chloroform vapor inhaled that regulating inhalers like the above can be only approximately accurate. Besides, as most chloroform accidents have occurred during the lighter stages of anæsthesia, the fact that an overdose cannot be given by a certain inhaler does not make an administration by that inhaler safe.

In administering chloroform by the drop-by-drop method, the mask is held a short distance from the face, a few drops are poured upon it, and the patient is encouraged to breathe naturally. After the patient has become accustomed to the vapor a steady and at first rather rapid dropping is kept up. When the stage of excitement arrives (in from three to six minutes) the dropping should be cautiously continued, and at any interruption of the respiration the administration should be temporarily discontinued. Otherwise, when breathing is resumed, the patient, with a deep inspiration, may inhale too much. The stage of excitement past, a constant dropping of the drug should be maintained in an effort to produce an even anæsthesia. As far as any rule can be given, a place on the gauze about the size of a twenty-five-cent piece should be kept constantly wet with chloroform. Careful and unremitting watch should be kept of the respiration, and this should not be neglected for the pulse, which is largely dependent upon efficiently performed respiration. The pulse may be counted by the quarter or half minute at the temporal, facial, or radial artery. If there is need of a more careful counting of the pulse, an assistant should be detailed for the purpose. The jaw must be held forward to keep the air-way patent, and a plentiful supply of air should be given. If oxygen is to be used, the rubber tube from the oxygen cylinder may be pinned or stitched into a hole cut in the top of the mask, and a fine, constant stream of oxygen turned on.

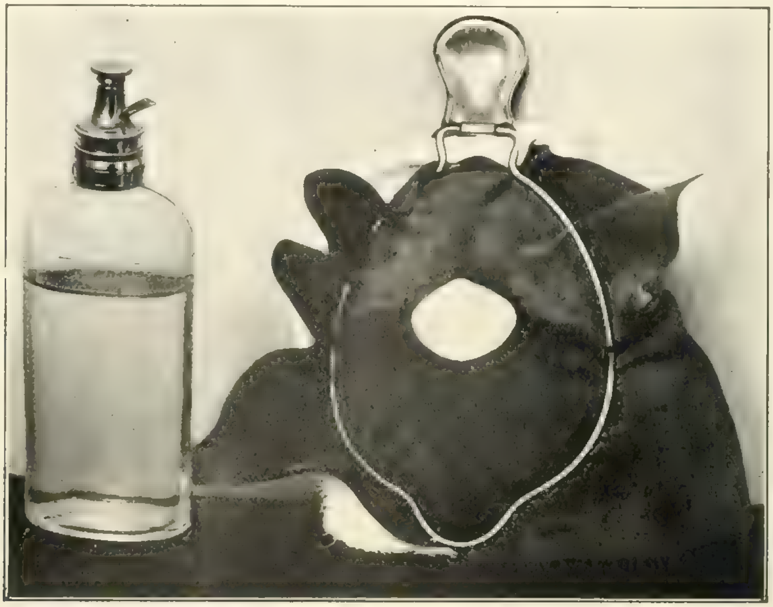

Fig. 82.—Schimmelbusch Mask and Drop Bottle, for Chloroform Mixtures.

The signs of complete anæsthesia under chloroform are:

1. Breathing regular, gently stertorous, and slightly accelerated;
2. Pulse slow and full;
3. Pupil contracted;
4. Conjunctival and corneal reflex absent;
5. Complete muscular relaxation.

When these signs are present, the head should be turned on the side and anæsthesia maintained as above described.

As pointed out by Hewitt, reflex disturbances of the respiration, which react dangerously upon the circulation, are more liable to occur during a light chloroformization than during a deep one. It is safer, therefore, to maintain a rather deep anæsthesia, while guarding against the reflex disturbances due to too little chloroform, on the one hand, and the results of an overdose, on the other.

The signs of too light an anæsthesia under chloroform are:

1. Breathing becoming slower, less audible, and shallow;
2. Pupils contracted or reflexly dilated and mobile;
3. Conjunctival and corneal reflexes return;
4. Swallowing reflex returns;
5. Retching and vomiting may occur, and are often attended by marked pallor.

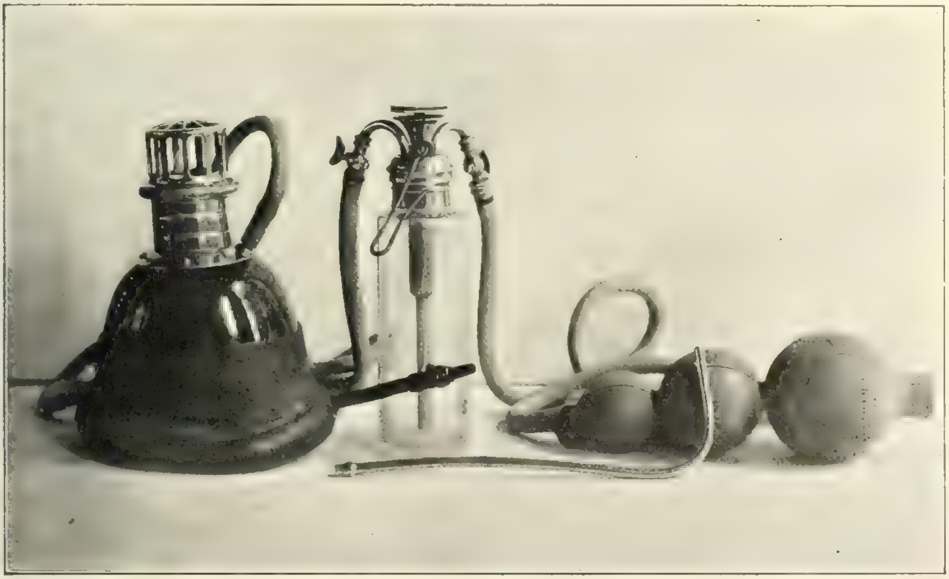

FIG. 83.—Krohne's Regulating Chloroform Inhaler.

The signs of too deep a chloroform anæsthesia are:

1. Shallow, gasping breathing;
2. Slow and feeble pulse;
3. Suddenly dilating pupils;
4. Marked pallor or duskiness and bad general appearance;
5. Absence of all eye reflexes.

These may go on to complete cessation of respiration and impairment or cessation of the heart's action.

A chloroform accident is very serious, and action must be prompt. Remove the inhaler, open the mouth, and draw forward the tongue, and at once begin artificial respiration by Sylvester's method. This should be carefully and deliberately performed and should be persisted in without interruption for at least half an hour. The foot of the bed or table may be slightly raised to allow the blood to go to the great centres in the medulla. Oxygen may be given as supplementary treatment. Nothing, however, should be allowed to interrupt artificial respiration. If there are signs of active circulation, one full dose of strychnine may be given hypodermically, but, as a rule, it is well to avoid the use of stimulants until the circulation is well established.

It is unsafe to administer chloroform to patients in the sitting posture or with the head too high, and in lifting chloroformed patients care must be taken to keep the head low. Chloroform causes dilatation of the blood-vessels, and, with the head too high, lessened supply of blood to the important centres in the medulla and encephalon may cause syncope.

MIXTURES OF CHLOROFORM AND ETHER.

There are in common use many mixtures containing chloroform, ether, and other drugs in varying proportions. Their action is essentially that of chloroform, the ether being added to support the respiration and circulation against the depressing effect of chloroform. The best of these mixtures are the A. C. E. and the C. E. mixtures, both of which are largely used in England, and "Anæsthol," which was introduced in 1898 by Dr. Willy Meyer, of New York. The ingredients of A. C. E. and C. E. should be freshly mixed and of the best quality obtainable.

The A. C. E. mixture consists of:

Alcohol	1 part	by volume
Chloroform	2 parts	
Ether	3 parts	

The C. E. mixture contains:

Chloroform	2 parts	by volume
Ether	3 parts	

"Anæsthol combines in a stable chemical union 17 per cent of ethyl chloride, 35.89 per cent of chloroform, and 47.10 per cent of ether, and possesses the distinguishing advantage of volatilizing at a temperature slightly above that of the body, so that its elimination is properly regulated by the lungs without imposing any strain on other parenchymatous organs, and accumulation or retention involving risk to the patient is excluded. It represents a clear, transparent fluid of agreeable odor, with a specific gravity very close to that of the blood and a B. P. of 104° F. (40° C.)." *

Safety of Mixtures.—Mixtures of chloroform and ether are safer than pure chloroform by as much as they contain more ether than chloroform. It has been argued, as against their safety, that the chloroform in a mixture is the last ingredient to evaporate and that patients are breathing pure chloroform during a large part of the administration. Practically, this is not true, especially in a mixture with a definite boiling-point and when administered drop by drop. No statistics have been prepared in regard to mixtures, but they are undoubtedly safer than chloroform, although not so safe as ether.

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* Quoted from circular accompanying the bottles.

Action and Mode of Administration of Mixtures.—On the respiration the action is essentially that of chloroform, with less liability to respiratory depression and irregularity. On the circulation the effect is like that of chloroform except that the pulse is not quite so slow and is of better quality. Post-anæsthetic sickness is generally very slight. It may, however, be severe like that following chloroform.

Mixtures should be administered by the open method, drop by drop, with a free air supply; although larger quantities and slightly more air-limitation will be found necessary than with chloroform. The best apparatus is a Schimmelbusch mask (Fig. 82), covered with six or eight thicknesses of gauze and a piece of rubber dam having a hole in the middle about one-half inch in diameter through which the mixture is dropped upon the gauze.

The same general rules govern the administration of a mixture as of chloroform, and the depth of anæsthesia is estimated by the same signs and symptoms. The essential differences are that the facial color and general appearance are apt to be better under a mixture than under chloroform; the respiration is rather deeper and the pulse fuller and not so slow.

Mixtures produce better results when used in connection with morphine and atropine. They are very useful for alcoholics, athletes, and difficult subjects generally; also for cases of cardiac, pulmonary, or renal disease requiring the use of an anæsthetic. Being not disagreeable to inhale they are useful for inducing anæsthesia preliminary to the employment of ether; and, being comparatively free from after-effects, they may be used alone in cases which have suffered severe post-anæsthetic sickness from chloroform or ether.

Accidents, if they occur, are apt to be circulatory in character, like those from chloroform, although the circulation is better maintained than in a chloroform accident. The treatment of accidents is the same as when chloroform has been used.

ETHYL CHLORIDE.

Ethyl chloride is a colorless, very volatile, inflammable liquid, with a specific gravity of .9214 at 0° C., which at 8° C. rises to .9176 (showing a striking increase in volume with increase of temperature). It has a low boiling-point (12.5° C.) and an odor, when the drug is pure, which is agreeable and ethereal, but which in most kinds of ethyl chloride is rather garlicky. If the drug is pure, the odor should be ethereal and the reaction to litmus paper should not be acid. It is decomposed by the action of light and air, and should be kept tightly corked in a cool, dark place.

For use as an anæsthetic the purest drug obtainable should be employed. It is sold by dealers, under various proprietary names, either in graduated glass vials containing 50 c.c., with patent stop-cocks which allow the escape of the drug in a fine stream, or in hermetically closed glass pearls containing 3 c.c., enough for an ordinary administration.

Safety of Ethyl Chloride.—In the matter of safety ethyl chloride is much inferior to nitrous oxide and not so safe as ether. It is safer than chloroform and than somnoforme. Ethyl chloride bears very much the same relation to nitrous oxide that chloroform does to ether.

Ware, of New York, in a series of 12,436 cases, including 1,000 of his own, reports one death. McCardie estimates the death-rate of ethyl chloride as one in 3,000 when the close method is used, and Lotheisen and Seitz as one in 16,000 with the semi-open method. This would seem to suggest the latter method as the safer. Practically, however, this is not true, owing to the imperfect anæsthesia, with excitement and struggling, that results from the semi-open method. While ethyl chloride has not stood the long test that nitrous oxide has, it may be said to be a reasonably safe anæsthetic for short operations or for use before the administration of ether. It is inferior to nitrous oxide from every point of view except that it does not produce cyanosis. Owing to its pungent and often garlicky odor it is not so agreeable to inhale as nitrous oxide, and patients who have taken both usually prefer the latter. It is, however, much more portable than gas, while the expense of the two agents is on the whole about the same.

Being exceedingly volatile and having a low boiling-point, ethyl chloride is very rapidly absorbed and equally rapidly eliminated. Anæsthesia, therefore, results very rapidly, and recovery is rapid, though less so than with nitrous oxide.

It stimulates respiration, increasing its rate and depth.

Its effect upon blood pressure is disputed. Seitz, of Constanz, claims that arterial tension is raised and cardiac action stimulated. It produces, however, dilatation of the peripheral arterioles, thus lowering blood pressure, although stimulating the heart. The respiratory centre seems to be affected before the cardiac, and therefore, in an accident, the heart would probably continue to act after cessation of respiration, thus making it possible to save the patient by artificial respiration.

Although recovery is rapid, it is by no means free from after-effects. Headache, nausea, vomiting, and dizziness are common, and in this respect the drug is much inferior to gas. The headache and nausea are sometimes persistent and severe, the writers having noted several such cases and McCardie reporting four.

Uses of Ethyl Chloride.—The principal uses of ethyl chloride are, in dentistry, for tooth extraction; in minor surgery, for painful dressings, for reducing dislocations, for operations not requiring muscular relaxation and not lasting for more than five minutes; in major surgery, for preceding the administration of ether.

Owing to its extreme volatility, ethyl chloride must be administered with almost complete exclusion of air, in order to produce satisfactory results. A good apparatus is an Ormsby's or Bennett's inhaler fitted with a small tube through which the drug may be sprayed into the rubber bag. Special inhalers have been devised for ethyl chloride and are possibly more convenient. Of these, Ware's (New York) inhaler is simple, clean, and effective (Fig. 84). It consists of a pliable rubber face-piece into the top of which fits a brass chimney, a diaphragm of fine-meshed gauze being placed between the two. Through the top of the chimney the drug is sprayed upon the gauze. The Bengué or "Narcotile" inhaler (Fig. 85) is more elaborate and more effective, being fitted with inspiratory and expiratory valves, and an inflatable rubber face-piece to provide for more complete air exclusion.

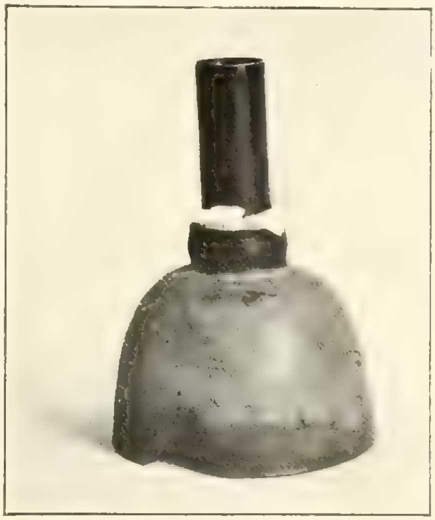

FIG. 84.—Ware's Ethyl-Chloride Inhaler.

The inhaler sold by the proprietors of somnoforme (Fig. 86) is an excellent one also for ethyl chloride and is well adapted for use of the ethyl-chloride pearls or capsules.

If a close inhaler is used, the patient should be made to breathe freely and regularly, and the bag should be inflated by applying the face-piece during several expirations. When the bag is seen to be moving with respiration, from 3 to 5 c.c. of ethyl chloride (10 c.c. in difficult subjects) is sprayed into the bag and the face-piece is closely applied. In from twenty-five seconds to one minute and a half, depending upon the patient and upon the amount of air exclusion, signs of anæsthesia will appear. The signs of complete anæsthesia under ethyl chloride are:

1. Respiration rapid, regular, and slightly stertorous.
2. Pupils dilated;
3. Eyeballs fixed and conjunctival reflex absent;
4. More or less muscular relaxation.

There is no cyanosis, although the facial color is heightened and a flush may appear on the neck and chest due to dilatation of the peripheral arterioles.

Difficult subjects may require an additional 10 c.c. before anæsthesia results.

The inhaler should now be withdrawn and the operation begun, or ether substituted, according to the purpose of the administrator.

An anæsthesia available for ordinary surgical purposes will continue for from one to three minutes after the withdrawal of the drug. This is a longer available anæsthesia than results from gas, and this constitutes a considerable advantage for ethyl chloride.

Muscular relaxation is usually imperfect, but will be more apt to result if morphine and atropine or hyoscine be given hypodermically half an hour before the administration. There is a striking absence of cyanosis, but often there is considerable slowing of the pulse-rate and diminution of volume, which seem to indicate diminished cardiac action and blood pressure.

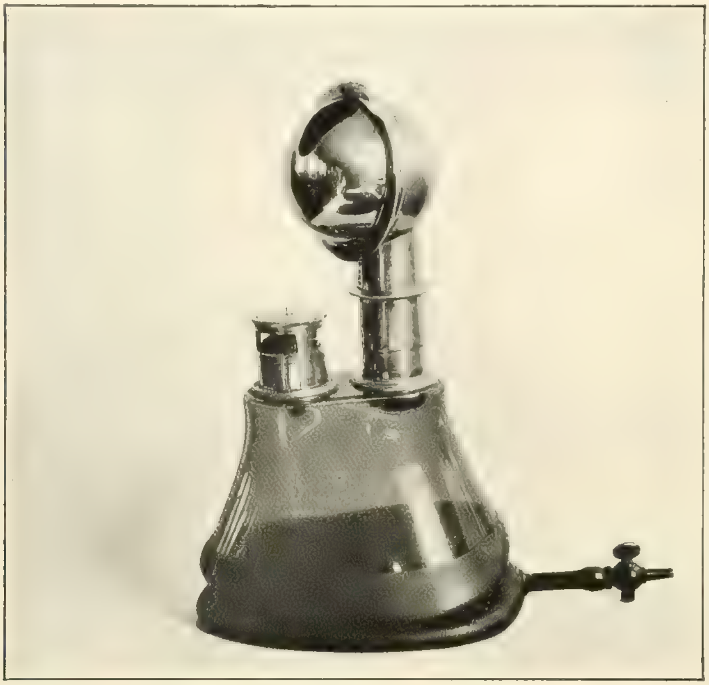

FIG. 85.—Bengué Inhaler, for Ethyl Chloride.

Ethyl chloride is unsuited for long operations, owing to the rapid and turbulent breathing which results when the necessary amount of air is admitted.

The *signs of an overdose* are:

1. Gasping breathing that continues as long as the drug is given in excess;
2. Bad general appearance, with pallor;
3. Widely dilated and non-reacting pupil.

Accidents are usually respiratory, like those of ether, but they may be accompanied by considerable impairment of the circulation. The treatment—artificial respiration, with plenty of air or oxygen—should be applied promptly and efficiently.

SOMNOFORME.

Somnoforme is a proprietary preparation which has lately come into prominence as a general anæsthetic. It was introduced by Dr. George Rolland, of Bordeaux, in France, and since its introduction it has been used considerably in this country and abroad. It is used chiefly for dentistry, but is good also in minor surgery and to precede ether.

Physiological Effects.—Somnoforme slightly increases the rate and depth of the respiration. The pulse is at first accelerated, but in many cases it becomes slowed, presumably owing to the ethyl bromide which it contains.

As it has been in use for only a short time, statistics in regard to its safety have little weight. In the pamphlet issued by the proprietors, for the purpose of advertising somnoforme, it is stated that in the cases superintended by Dr. Rolland "he has never seen the slightest alarming symptoms during the many thousands of cases which he has personally observed and controlled." On the other hand, Dr. Hewitt, writing in 1904, says: "The so-called somnoforme does not produce such good results as pure ethyl chloride and is distinctly more dangerous. Three deaths have already taken place in Great Britain from somnoforme."*

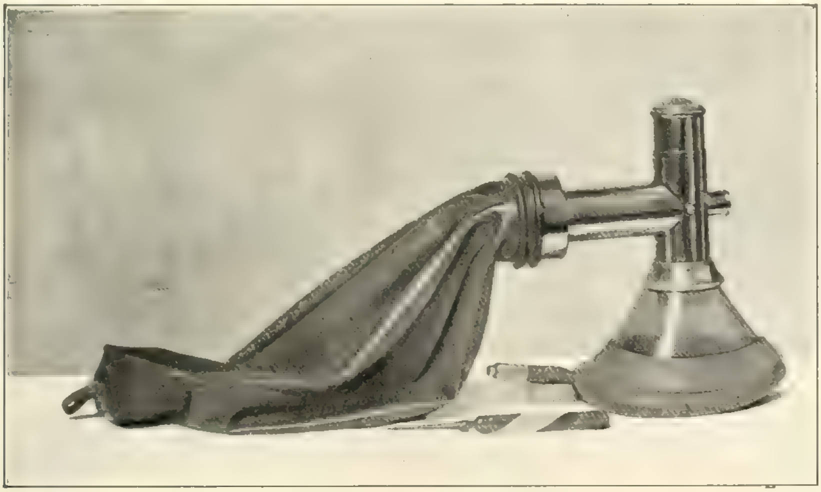

FIG. 86.—Somnoforme Inhaler and Capsule.

Somnoforme is sold in graduated glass bottles with patent stoppers through which the drug is liberated in a fine stream; it is also sold in small glass pearls or capsules of two sizes (3 c.c. and 5 c.c.) that contain enough for one administration.

Somnoforme can be satisfactorily administered with a Bennett, Clover, or Ormsby's ether inhaler, so modified that the drug may be sprayed upon gauze near the mouth of the rubber bag of the inhaler. The proprietors sell a special inhaler for the use of somnoforme, which has the advantage that the capsules containing the drug can be broken into the inhaler without danger of the glass being inhaled.

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* Lancet, 1904: 11 1486

This inhaler (Fig. 86), called "deTrey's somnoforme inhaler," consists briefly of a face-piece with inflatable rubber rim; a patent stop-cock provided with a hole through which the drug may be sprayed upon lint or gauze; and an inflatable rubber bag. It is, in effect, a close inhaler, and may be used equally well for somnoforme or for ethyl chloride.

In an administration of somnoforme, from 3 to 5 c.c. is sprayed upon the lint through the hole in the stop-cock. The patient is instructed to breathe freely, and while he is breathing in this manner the face-piece is applied, during an expiration, and at the same time the rubber bag is allowed to become filled with somnoforme vapor. In the next following inspiration, therefore, the patient will inhale pure somnoforme vapor.

Anæsthesia is produced in a strikingly rapid manner by somnoforme. Daniels, in an analysis of 100 administrations, gives the induction period as from 25 to 100 seconds. The proprietors claim an average of 30 seconds. It may be said to vary from 30 to 120 seconds, according to the patient and the amount of air-limitation practised.

The *signs of complete anæsthesia under somnoforme* are:

1. Accelerated and slightly stertorous respiration;
2. Dilated pupil;
3. Loss of conjunctival reflex;
4. More or less muscular relaxation.

Somnoforme does not produce cyanosis.

The inhaler may now be removed and the operation begun, or ether may be substituted, according to the purpose with which the anæsthetic is given.

The available anæsthesia that results often continues for a remarkably long time. Daniels found the period to vary from 10 to 180 seconds, with an average of 64 seconds. The proprietors claim an average of 76 seconds.

Post-anæsthetic Effects.—Nausea and vomiting are not common (one per cent), but persistent headache and giddiness frequently result, and the recovery from somnoforme is not so prompt and normal as is that from nitrous oxide.

IV. THE ADMINISTRATION OF ANÆSTHETICS IN SEQUENCE.

To meet various indications that occur in practice, anæsthetics are often administered in sequence, that is, one after another, in the same case. Ether, for example, is disagreeable to inhale, causing coughing, salivation, the secretion of mucus, excitement, and struggling, and requires considerable time for producing complete anæsthesia. Therefore, other anæsthetics are used to precede ether and do away with these disadvantages.

Certain cases of heart and lung disease requiring anæsthetics should be anæsthetized with the least possible strain on the respiration and circulation, and may require chloroform or a mixture before ether is administered. Thus, we speak of various sequences as the

Nitrous oxide-ether sequence;
Ethyl chloride-ether sequence;
Somnoforme-ether sequence;
A. C. E.-ether sequence;
Chloroform-ether sequence;
Nitrous oxide-ether-chloroform sequence;
A. C. E.-ether-A. C. E. sequence.

Chloroform and its mixtures cannot be used in sequence to nitrous oxide, ethyl chloride, or somnoforme, on account of the circulatory depression that would result from a rapid administration of the large amount of chloroform necessary to control the patient.

The *nitrous oxide-ether sequence* was introduced by Clover, of London, in 1876. It is a very safe method, and in healthy patients safer than the use of ether alone. The advantages of the method are: It is safe; it spares the patient the disagreeable sensations of inhaling ether; it requires a very short time, *i.e.*, from one to four minutes, for the production of complete anæsthesia; finally, it lessens the amount of ether used and diminishes post-anæsthetic sickness.

There are two methods of using the nitrous oxide-ether sequence, viz., the open method and the close method.

In the open method a full dose of nitrous oxide from any gas inhaler is given, and then a semi-open inhaler charged with ether is applied. This method is useful for alcoholics, athletes, or difficult subjects, as they can be put deeply under gas before ether is used. As soon as rapid and stertorous breathing, with cyanosis and jactitation, occurs under gas, the change to ether should be made, the ether inhaler being kept closely applied until complete ether anæsthesia results.

In the second or close method, a combined gas and ether inhaler (such as the Clover, Hewitt, or Bennett) is used. The administration by the Bennett inhaler is given in the words of the circular that accompanies each inhaler:

> *Gas and Ether.*—The ether inhaler (Fig. 87) is charged with ether and arranged as described on page 192, the bag being omitted. The gas inhaler is arranged as described on the same page, the bag being completely filled with gas and disconnected from the tube at the stop-cock *F*, which is to be closed. The gas inhaler is now connected with the chimney of the ether inhaler. The face-piece being perfectly applied, the tap *E* is closed and gas is breathed through valves. When the gas bag has been two-thirds or three-fourths emptied, the aperture *D* is closed by turning the thumb-screw of the gas inhaler. Gas is now breathed back and forth. The patient is at this time unconscious, or nearly so, and ether is to be turned on as described on page 193, though somewhat faster. In about one minute signs of complete gas

anæsthesia will appear if the face-piece has been well applied (cyanosis, jerky, snoring respiration, twitching movements in the extremities) and are to be met by opening the tap *E* for two or three respirations. The tap is again closed, and the inhalation of gas plus ether is continued, an occasional breath or two of air being allowed. In this way the gas anæsthesia subsides, while the ether narcosis becomes complete. After about one minute and a half the gas may be discontinued, the gas inhaler and bag should be removed, and the ether bag substituted. The administration now proceeds as described on page 192.

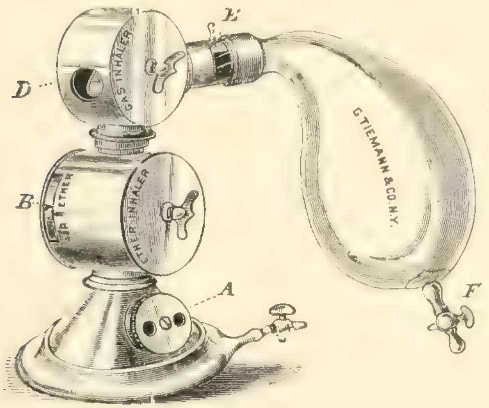

FIG. 87.—Apparatus for the Administration of Gas and Ether.

In most cases one bag full of gas (two gallons) is sufficient, but in difficult subjects the bag may be left connected with the cylinder and a constant flow of gas continued until distinct signs of gas anæsthesia appear.

In the *ethyl chloride-ether sequence* from 3 to 5 c.c. of the drug is sprayed into a Ware's, Bengué, or somnoforme inhaler and administered until the patient is unconscious, as shown by rapid, stertorous breathing and dilated pupil. A change is then made to ether, which should be given on a semi-open or close inhaler and pushed to complete anæsthesia. Anæsthesia usually results very rapidly, patients being made ready for operation in from two to five minutes.

The *somnoforme-ether sequence* is administered in the same manner as the ethyl-chloride sequence, a somnoforme inhaler being used for the purpose.

By fitting the Bennett ether inhaler with a small tube at the neck of the ether bag, to which the vial containing ethyl chloride or somnoforme may be connected and sprayed into the bag, we have a very suitable apparatus for either of these sequences. When signs of anæsthesia occur, the administration of ethyl chloride or somnoforme is discontinued and ether is turned on from the previously charged ether chamber.

The A. C. E. or the Anæsthol or the chloroform-ether sequence is useful in difficult subjects, such as athletes, alcoholics, and obese patients, and in many cases of disease of the respiratory and circulatory systems in which it is important to avoid undue stimulation of the respiration or circulation. The chloroform seems to produce exactly the form of anæsthesia which is necessary for controlling these patients, while the ether counteracts any depression of respiration or circulation.

The mixture or chloroform is given by the constant-drop method on an Esmarch or Schimmelbusch mask. The administration should be rather rapid at first until the respiration becomes regular and faintly stertorous, or until signs of excitement or rigidity begin—a change which usually takes place in from three to five minutes. Ether on an open or a semi-open inhaler is then substituted, care being taken to avoid the reflex holding of the breath which follows when too concentrated an ether vapor is given.

Complete anæsthesia usually results in from four to six minutes, and, as a rule, there is no coughing, no excess of mucus or saliva, nor any struggling. At the beginning of the administration the same precautions as to respiration and pulse are necessary as in the administration of chloroform.

Post-anæsthetic sickness is less common than when chloroform or ether alone is used.

In the nitrous oxide-ether-chloroform sequence the procedure is the same as in the nitrous oxide-ether sequence. After the required dose of ether has been given, three or four inspirations of fresh air are allowed, and then chloroform is administered on an Esmarch or Schimmelbusch mask, gradually at first and then more rapidly, and continued as in a simple chloroform administration. The ether stimulates the circulation and respiration and makes the subsequent use of chloroform safer.

V. CHOICE OF ANÆSTHETIC AGENTS AND METHODS.

Obviously, in selecting an anæsthetic, the first consideration should be the question of its safety. Yet, because one agent is statistically safer than another, it does not follow that it is safer in every case.

To obtain the best results the anæsthetist should personally examine and direct the preparation of his patient, carefully studying the case as to age, physical and mental characteristics, history of previous anæsthesias, general condition, etc., before deciding upon the agent and method to be used. The operation should also be considered as to the anatomical field, the posture which will be required, and the probable duration and depth of anæsthesia that will be necessary. With diseased patients who require anæsthetics, great care in the preparation of the patient and the proper selection of the anæsthetic is necessary.

It should be remembered that the anæsthetic state is always unsafe, and especially so in the critical cases about to be described. Therefore every minute less of anæsthesia is in the patient's favor, and the administration should never be commenced until the surgeon is ready to begin operating. Even in normal subjects it is entirely unwarrantable that patients be anæsthetized several minutes before the operation is begun, and in diseased patients it is hazardous.

ANÆSTHETIZATION OF INFANTS AND CHILDREN.

Nitrous oxide should not be used in infants. It produces asphyxial symptoms very rapidly, and involuntary micturition is apt to occur. It is also unnecessary, as infants and very young children often have no remembrance of inhaling anæsthetics. Chloroform is no safer in infants and children than in adults, except that resuscitating measures are more easily performed in the former. Mixtures given by the open method, drop by drop, work well and produce less irritation of the respiratory passages than ether.

Infants and children can be easily chloroformed while asleep, if sufficient care be used, and then a change made to ether. Ether by the open method is the safest routine method for anæsthetizing infants. There are some, however, who consider chloroform safer in youth than in adult life, because of the acquired tissue changes, in the latter period, which contribute to conditions believed by many to contra-indicate the use of chloroform.

In the older children nitrous oxide may be used, although when under five or six years old they may have screaming, cyanosis, involuntary micturition, jactitation, and sometimes even opisthotonos. Just enough nitrous oxide to produce loss of consciousness should be given, with a view to avoiding these symptoms. The apparatus often frightens them and they may have to be firmly held in order to allow a proper approximation of the face-piece.

Ethyl chloride works well and is safe in children. If they can be pursuaded to inhale two or three breaths, anæsthesia will result rapidly, usually without struggling or cyanosis.

Children who are obstinate or terrified should always be firmly restrained and consciousness overcome as rapidly as possible by nitrous oxide or ether. Anæsthetic mixtures and chloroform should not be used upon crying and struggling children, as it is difficult to gauge the amount that is being inhaled, and consequently overdosing may result.

A good way to induce anæsthesia in timid children is by means of a few drops of A. C. E. on a handkerchief or mask, ether being then used to deepen and maintain the anæsthesia.

Chloroform may well be avoided in children unless necessary, on account of frequent bronchial irritation, etc.

In general, the best and safest method for children is to give ether by the open or semi-open method, preceded in younger children by an anæsthetic mixture and in older ones by nitrous oxide.

Morphine and atropine may be cautiously used in older children, *i.e.*, children over ten or twelve years, and then in very small doses, $\frac{1}{20}$ to $\frac{1}{12}$ of a grain of morphine with $\frac{1}{300}$ of atropine being enough. Atropine given by the mouth twenty minutes before administering the anæsthetic will prevent the excessive secretion of mucus and saliva so common in children.

ANÆSTHETIZATION OF AGED PATIENTS.

Patients over sixty years of age are apt to have respiratory troubles such as asthma, chronic bronchitis, etc., or senile changes in the circulatory system, as arteriosclerosis, etc. It is desirable, therefore, to select anæsthetics that will cause tranquil respiration and not overtax the circulation. This cannot well be done with gas or ether when used from the beginning. Chloroform usually acts well in the aged and is safer than in youth or middle age, because respiratory embarrassment is less apt to occur, although the behavior of the circulation, and especially that of the heart, should be carefully watched for signs of overdose. Oxygen adds materially to the safety. Anæsthetic mixtures also act well and produce a slightly more vigorous respiration and circulation, which may be desirable in some cases. Speaking generally, the chloroform element is more desirable in the aged than the ether, although the latter is by no means contra-indicated. The chloroform-ether sequence or the A. C. E.-ether-chloroform sequence is usually satisfactory.

In regard to sex, women are easier to control by anæsthetics than men. They are much more apt to exaggerate the disagreeable effects of inhaling ether or chloroform, and consequently these agents should usually be preceded by nitrous oxide, ethyl chloride, or somnoforme.

ANÆSTHETIZATION OF SO-CALLED "DIFFICULT SUBJECTS."

Some patients are difficult to control by anæsthetics. Alcoholics, excessive smokers, strong, athletic, nervous, high-colored, full-blooded persons; persons who lead out-of-door lives; obese, high-living persons; short, thickset, short-necked persons, as a class, afford familiar examples of difficult subjects.

Negroes are apt to be difficult subjects. They are usually nervous and tend to secrete large quantities of mucus especially when under ether.

Full beards or mustaches may cause difficulties by interfering with the proper control of air which enters about the hair. Under nitrous oxide difficult subjects show intense cyanosis, rigidity, jactitation, struggling, etc., and they recover almost immediately from anæsthesia. Under ether they develop marked excitement, struggling, cyanosis, and an excess of mucus and saliva; the respiration is rapid, turbulent, and loudly stertorous; the pulse is full, rapid, and bounding; and it is almost impossible to produce muscular relaxation. Under chloroform, excitement and struggling, cyanosis, respiratory spasm, and lack of muscular relaxation occur. Such persons consume enormous quantities of any anæsthetic, recover quickly, and usually have little, if any, post-anæsthetic sickness.

If difficult subjects have also deviations of the nasal septum, enlarged lower turbinates, collapsed nasal alæ, enlarged tonsils, or adenoid vegetations, the difficulties are much increased. These difficulties can be largely avoided by having at hand *tubes* of soft but firm rubber which can be passed along the floor of the nasal passage. These should be sufficiently large (about three-eighths of an inch for adults) to insure good breathing space, and long enough to reach from the vestibule of the nose to below the soft palate. If the operation is to be about the mouth, the tubes may be extended to the level of the epiglottis, and the pharynx packed with gauze, as advocated by Crile. Before they are used, the tubes should be thoroughly cleansed and an antiseptic lubricant applied.

In administering gas to difficult subjects, an accurately fitting face-piece should be used and air-exclusion carefully practised for the first few respirations. Large quantities of gas (say, six or seven gallons) may be necessary to induce anæsthesia, and a steady stream, sufficiently vigorous to cause a slight positive pressure of gas in the bag, should be kept flowing. A semi-open or close inhaler, fully charged with ether, may then be substituted.

It is usually very difficult to induce anæsthesia with ether in these subjects, owing to the excitement, struggling, coughing, rigidity, cyanosis, etc., which occur, and to the enormous quantities of the anæsthetic necessary. For maintaining anæsthesia induced by gas or chloroform, ether in a semi-open or close inhaler may be used. With the close method, cyanosis, very exaggerated breathing, and rigidity are apt to occur, and the writers believe that the semi-open method, although consuming larger quantities of ether, produces better results in these patients, especially if used in conjunction with morphine and atropine.

Chloroform is particularly dangerous to use in this class of patients owing to the frequency of struggling and excitement, the spasmodic arrest of respiration, etc., that occur during its use. It may be employed to induce anæsthesia, as may also mixtures, if used with caution. It should be given rather rapidly for one to two minutes, and then a change should be made to ether the moment the respiration becomes regular or any signs of struggling appear. The ether may be given with plenty of air on a strongly charged semi-open inhaler until the stage of excitement has subsided.

The best methods to use in difficult subjects are the nitrous oxide-ether-chloroform sequence, and the A. C. E.-ether-chloroform sequence, used in conjunction with morphine and atropine. A relatively large dose of morphine and atropine should be given half an hour before starting the anæsthetic, and the sequences administered in the manner already described.

Intensely nervous and terrified patients, such as hysterical women, may refuse or be unable to keep the head still long enough to permit of a successful induction of anæsthesia by nitrous oxide. These patients may either be systematically restrained and put rapidly under the influence of the gas or gradually anæsthetized by A. C. E. or chloroform. If the latter method is employed, plenty of air should be allowed and the patient constantly encouraged and reassured; at the same time the drug should be administered freely, in order to secure anæsthesia as quickly as possible.

THE CHOICE OF METHODS FOR DIFFERENT OPERATIONS.

Certain operations, on account of anatomical location or the posture of the patient during the operation, require special methods. The following classification gives the most important of these operations:

Operations of Cerebral Surgery.

These patients are usually very easy to control, require little of the anæsthetic, and are easily over-anæsthetized. Therefore, the anæsthetic should be administered sparingly and cautiously.

It is well to avoid nitrous oxide, as it raises arterial tension and may start up bleeding. It is also unnecessary, as these patients are often more or less unconscious. Ether should not be given from the beginning, on account of starting up bleeding and struggling. As a rule, chloroform or a mixture is the best agent to use. It should be given drop by drop, and may be followed by ether if circulatory or respiratory depression appear.

As a rule, mixed anæsthesia should be avoided, especially if there is shock or coma. It may be useful, however, in patients who are violent or delirious before operation. It tranquillizes the patient and lessens bleeding.

Ophthalmic Operations.

These operations are mostly of short duration and require only light anæsthesia; indeed, in not a few cases local anæsthesia suffices. Iridectomy and enucleation of the eye have been done under nitrous oxide, nitrous oxide and oxygen, ethyl chloride, or somnoforme. As a rule, however, ether or chloroform will be found necessary. It is important to give the surgeon as clear a field as possible—a thing which is hard to do with an inhaler on the face. Patients may be profoundly anæsthetized with ether, and the operation performed during the anæsthesia that results after the withdrawal of the inhaler. The selection of the anæsthetic depends more upon the patient's general characteristics than upon the operation.

If rectal anæsthesia were simpler and safer, it would, of course, be ideal for ophthalmic practice.

Operations of Aural Surgery.

Paracentesis of the membrana tympani may be easily done under nitrous oxide (with or without oxygen), ethyl chloride, or somnoforme, or under a light ether or chloroform anæsthesia.

Mastoid operations, however, require a deep anæsthesia with ether, chloroform, or an anæsthetic mixture. There is, of course, less bleeding after the latter, and a good general method might be the nitrous oxide-ether-chloroform (or mixture) sequence. Morphine and atropine are helpful in small doses, lessening the bleeding and the necessary amount of the anæsthetic.

Operations of Oral and Nasal Surgery.

In these operations the posture of the patient is important. We recognize in general four positions:

1. Dorsal with head extended;
2. Trendelenburg;
3. Sitting or "bent forward";
4. Lateral.

The *dorsal posture* allows drainage through the nose and gives an excellent view of the back part of the mouth and pharynx. If, however, there is nasal obstruction, blood or pus may collect in the naso-pharynx and require careful and constant sponging.

The *Trendelenburg posture* provides good drainage away from the larynx, but has the disadvantage of increasing hemorrhage.

In the *sitting posture* the patient is placed upright in a firm chair, with a pillow or the anæsthetist's knee as a support for the back. Drainage is obtained by tilting forward the patient's head at intervals. This posture contraindicates the use of chloroform.

In the *lateral posture* the patient is placed on his side and the head raised by a pillow until it is in line with the body. Excellent drainage into the lower cheek results, and coughing and swallowing are not interfered with. The posture is rather awkward, however, for some operators, who find it difficult to obtain a good view of the back of the mouth.

In any of these postures, profound anæsthesia with ether, following nitrous oxide, ethyl chloride, somnoforme, or a chloroform mixture, is the rule. If the cautery is to be used, a change to chloroform should be made two or three minutes beforehand.

Operations around the Nose and Throat.

Tonsils and Adenoid Vegetations.—In these operations the employment of ether, preceded by a small amount of gas, except in very young children, is the best method. The patient should be placed in the upright posture, and the head and body rapidly tilted forward whenever the throat fills with blood. The anæsthesia should be light.

Intranasal Operations.—These include operations for polypi and for deviations of the septum, turbinotomies, etc. On account of the nasal obstruction which exists in such cases, A. C. E. rather than nitrous oxide should be used to induce anæsthesia, which is to be maintained by ether. The sitting posture is the best, but if A. C. E. has been used the patient should be anæsthetized in the dorsal posture and not placed upright until he is well under the influence of the ether.

Operations on the Antrum of Highmore.—These cases are trying to the anæsthetist, whose best procedure is to use the nitrous oxide-ether sequence until profound anæsthesia is secured, after which the effect may be maintained by the Greene thermo-ether inhaler.

The best position is the lateral, with the posterior nares plugged with gauze.

Cleft-Palate Operations.—Continuous deep anæsthesia is absolutely necessary in these operations, and is best accomplished in the manner described under "Operations on the Antrum." The patient should be placed in the dorsal posture slightly modified by the Trendelenburg position, and with the head in extreme extension. The tongue should be held forward by a ligature passed through the median raphe.

Operations on the Lips and Cheeks.

In these the patient should be placed in the lateral posture and the gas-ether sequence should be employed. In some cases where bleeding is profuse, the nasal tubes described on page 214 may be introduced and carried back as far as to the epiglottis, the back of the mouth being packed with gauze.

Extirpation of the Tongue.

This operation is usually performed for malignant disease and in patients who are advanced in years.

It may be done in the upright, lateral, or Rose's posture. The latter posture, in which the head is in extreme hyperextension and the shoulders well propped up, is preferred by some surgeons owing to the fact that no blood can be swallowed or inhaled. The writers prefer the upright posture, however, and believe the following to be the best method of procedure:

A relatively large dose (gr. $\frac{1}{6}$—$\frac{1}{4}$) of morphine with atropine should be given half an hour before the anæsthetic is administered. The patient being recumbent, anæsthesia should be induced with a chloroform mixture, and then, as soon as consciousness is lost, ether dropped on a semi-open inhaler should be substituted. When profound anæsthesia is obtained the patient may be placed upright and strapped in the operating chair, the head being properly supported and neither flexed nor extended. The anæsthetist, standing behind or to one side of the patient, may hold the head himself or detail an assistant for this purpose. Anæsthesia may be maintained by the Greene thermo-ether inhaler, a gag or mouth-prop holding the mouth open and allowing the surgeon to work without interruption; or the anæsthetic may be entirely withdrawn when the surgeon begins operating, and reapplied when the patient shows signs of commencing recovery. Owing to the action of the morphine, patients will often remain anæsthetized for fifteen or twenty minutes, or even longer, allowing the surgeon to complete the operation without interruption. Rectal anæsthesia has been successfully used in these cases, and would, of course, be the ideal method were it not for its difficulties and dangers.

Operations on the Neck.

1. *Tracheotomy.*—This operation is best performed under cocaine anæsthesia, but is frequently done under general anæsthesia, as a step in the operation of *laryngotomy* or *laryngectomy*. The best anæsthetic to use in these operations is chloroform or a mixture containing it, and the best posture is the Trendelenburg. This prevents blood and mucus from entering the lungs and makes the maintenance of anæsthesia by chloroform safer.

The tracheotomy tube having been inserted, anæsthesia may be maintained by chloroform given on an Esmarch mask held over the tracheotomy tube or by Krohne's regulating chloroform inhaler fitted with the bent silver tube (Fig. 83).

2. *Thyroidectomy* calls for a careful selection and administration of the anæsthetic, especially if the growth is large enough to press upon or dislocate the trachea.

Nitrous oxide is usually contra-indicated in these cases owing to the liability to asphyxia that results from delayed elimination of the gas.

Ether also is unsuitable, as it produces engorgement of the mucous membrane of the upper respiratory passages and consequently increases narrowing of the air-way.

Chloroform or a chloroform mixture is to be preferred, as it produces no engorgement and does not cause cough or the excessive production of mucus or saliva.

Before starting the anæsthetic in neck cases, it is important thoroughly to loosen or cut away all bandages about the neck, and at the conclusion of the operation to guard against too tight bandaging.

A good method of procedure is to give a dose of morphine with atropine half an hour before beginning the administration. The patient should be allowed to adopt the position in which breathing is easiest, and as many pillows as he desires may be allowed.

Anæsthesia should be induced with chloroform or with an anæsthetic mixture, which may be continued throughout the operation, a change being made to ether if too great circulatory or respiratory depression occurs. When anæsthesia is complete the head may be extended, as required by the surgeon, by removing one by one the pillows.

In all operations of this nature the surgeon or the anæsthetist should be prepared for immediate tracheotomy.

In thyroidectomy for exophthalmic goitre, the tachycardia adds considerable danger to the operation, and therefore the circulation must be carefully watched. The mode of procedure is the same.

3. *Operations for diseased lymph nodes in the neck* often present difficulties to the anæsthetist, persistent cyanosis, excessive secretion of mucus, and respiratory spasm being the commonest. The preliminary use of morphine and atropine tends to do away with the superabundant mucus and the spasm, but in order to keep the color good the use of oxygen may be necessary. These patients are often the subjects of tuberculosis and will secrete mucus freely, especially if ether is employed.

The use of morphine and atropine and a careful administration of a chloroform mixture are to be recommended in these cases. The A. C. E.-ether sequence may work well, or the nitrous oxide-ether-chloroform sequence may be tried, although, as a rule, it is well to avoid the use of gas.

Operations Requiring the Prone Posture.

The prone posture interferes considerably with respiration, complete chest expansion being impossible. This must be compensated for by maintaining a light anæsthesia, which can be safely done owing to the good drainage for mucus, vomitus, etc., that the prone posture insures. Anæsthesia should be induced in the dorsal posture, and the patient deeply anæsthetized; then he should be turned into the prone posture, after which the anæsthesia may be allowed to become much lighter.

Among operations requiring this posture may be mentioned laminectomy and Kraske's operation for resection of the rectum. The subjects of both of these operations are apt to be weakened by disease, and hence great care on the part of the anæsthetist is necessary under these circumstances. The circulation should be carefully watched for signs of shock and hemorrhage, and over-anæsthetization should be guarded against. Ether should be used for maintaining the anæsthesia. It may be wise in some cases of laminectomy, especially those at the upper dorsal and lower cervical region, to draw the body upward so that the upper thorax can be supported by an assistant, thus removing the weight of the body from the table, and, so far as possible, any interference with the crippled respiratory act.

Abdominal Operations.

Abdominal operations require profound anæsthesia with complete muscular relaxation and tranquil respiration. This rules out nitrous oxide as an agent for maintaining anæsthesia in abdominal surgery, although in certain favorable subjects nitrous oxide and oxygen will produce muscular relaxation.

Ether or chloroform is the best agent to use, and morphine and atropine may be necessary to insure quiet breathing and muscular relaxation. Ether is, on the whole, to be preferred, as circulatory depression is less likely to occur than with chloroform. In many cases, however, ether fails completely to relax the muscles, and chloroform becomes necessary. Anæsthesia may be induced by any agent that the patient's physical characteristics seem to call for. The nitrous oxide-ether, the nitrous oxide-ether-chloroform, and the A. C. E.-ether sequences, in conjunction with morphine and atropine, may all be used to advantage in abdominal surgery.

Operations Requiring the Lithotomy Posture.

These operations can usually be done under a light anaesthesia. This is especially true of the common gynaecological operations, such as—

Dilating and curetting, and

Repair of the cervix and perineum.

In such a series of operations a very light anaesthesia would suffice for the first two procedures, while for the perineal operation the anaesthesia would have to be deepened several degrees.

The operations for hæmorrhoids, whether by clamp and cautery or by excision, require a deep anaesthesia at first and during the stretching of the sphincter. In the latter part of the operation, however, the anaesthesia can be lightened several degrees.

Perineal urethrotomy can be done under a fairly light anæsthesia.

As a rule, a mixture of gas and ether by the close method works well in these operations.

In the Sims, lateral, or prone postures, excellent drainage is provided for mucus, saliva, or vomitus, and a light anæsthesia can be easily maintained. It must be remembered that the movements of the thorax are considerably limited in these postures, and over-anæsthetization should be guarded against.

Amputations, Reduction of Dislocations, Setting Fractures, etc.

Amputations should be performed under a light anæsthesia. The patients are often in a state of shock or weakness, and ether is the best anæsthetic, except in cases of senile gangrene with arterial disease, when chloroform is to be preferred. Muscular relaxation is not always necessary; otherwise a light anæsthesia should be maintained.

For the reduction of dislocations and the setting of fractures, more profound anæsthesia is necessary. Ether is usually sufficient, although, when complete relaxation is necessary, ether may be supplemented with chloroform.

VI. DISEASES AND CONDITIONS REQUIRING SPECIAL METHODS.

Anæmia.

Anæmic patients are, as a rule, easily controlled by anæsthetics. In moderate anæmia no change from routine methods is necessary. In pronounced anæmia nitrous oxide and all methods requiring limitation of air are contra-indicated owing to the rapid development of asphyxia which results in these cases. Ether is well borne, but should be administered by the open or semi-open method and in the smallest possible quantity. Chloroform is best avoided in anæmia, and, if it be used, great caution is necessary. Ethyl chloride and somnoforme are very well adapted for inducing anæsthesia in these cases, as they do not produce cyanosis nor asphyxial phenomena. The less the percentage of hæmoglobin in the blood the less will be the necessary quantity of the anæsthetic.

ANEURISM AND ATHEROMA.

In these cases the indication is to secure a tranquil anæsthesia without excitement, struggling, or undue stimulation of the circulatory system.

Nitrous oxide, although it may eliminate excitement and struggling, increases arterial tension and is therefore best avoided.

Ether should not be used owing to its exceedingly stimulating effect upon the circulation and its liability to produce struggling.

Chloroform or a mixture is the best anæsthetic for these cases. It should be used in conjunction with morphine and atropine, which should be given twenty or thirty minutes before the administration of the anæsthetic. The anæsthetic should be given rather rapidly at first, in an effort to avoid undue excitement and struggling. Should these occur, however, the administration should be cautiously continued as described under "Administration of Chloroform."

ASTHMA.

Morphine and atropine should be given to diminish secretions and tranquillize the respiration.

Nitrous oxide and all close methods are contra-indicated.

Ether should not be used to induce anæsthesia, although it may be well borne in sequence to chloroform.

Chloroform or a chloroform mixture should be used to induce anæsthesia; and, if well borne, it may be continued throughout the operation. But if it is not well borne, a change to ether should be made.

For short operations ethyl chloride or somnoforme is well taken by asthmatics.

Posture is important while inducing anæsthesia, and as many pillows as the patient requires in order to breathe comfortably should be allowed. These may be removed when consciousness is lost.

BRONCHITIS.

In acute bronchitis operative interference should be deferred, if possible. If it cannot be deferred, chloroform or a chloroform mixture is the best anæsthetic, unless the operation is a trivial one, when nitrous oxide can be safely used.

In chronic bronchitis it is well to avoid nitrous oxide and all close methods except in short operations.

Ether should not be used at first, although it may work well in sequence to chloroform.

Chloroform or a mixture, used in conjunction with morphine and atropine, is the best method for these cases.

Carbuncle.

Patients with carbuncle are often exhausted by pain and lack of sleep and may have considerable shock during anæsthesia.

The operation should be done as rapidly as possible under a light anæsthesia by nitrous oxide, nitrous oxide and ether, or ether.

Diabetes.

Diabetics should be carefully dieted for several weeks before operation, if possible, in order to reduce to a minimum the sugar in the urine.

The danger in anæsthetizing diabetics is coma, and therefore a light and brief anæsthesia is imperative.

Nitrous oxide sometimes produces temporary glycosuria in health and therefore should be avoided.

A light narcosis with ether or with a mixture containing chloroform is the best line of practice.

Dyspnœa.

In dyspnœa the selection of the anæsthetic varies, of course, with the cause. Generally speaking, it is best to induce and maintain anæsthesia by chloroform or a chloroform mixture, as these throw the least possible strain upon the respiration.

In the giving of an anæsthetic, in cases of laryngeal obstruction, the symptoms are often so much aggravated thereby as to demand prompt operative relief. Therefore the preparations to meet this complication should be complete and at hand.

Posture is very important, and the patient should be allowed to adopt any attitude in which he can breathe most comfortably. As soon as consciousness is lost the posture may be changed to suit the requirements of the operation.

Oxygen should always be at hand.

EMPYEMA, PLEURISY, ABSCESS OF LUNG, ETC.

Simple paracentesis of the thorax for pleurisy can be done under cocaine or under a light anæsthesia resulting from gas, ethyl chloride, somnoforme, or ether.

In all operations upon the thorax, posture is of the utmost importance. Usually one side only of the thorax is able to expand, and the posture should be such as to give the sound side the best possible chance. The placing of the diseased side uppermost prevents the expansion of the only available side of the thorax, and cases have been reported in which, under these circumstances, pus from an abscess in the lung drained into the sound lung and suffocated the patient.

Therefore the sitting posture, or the lateral posture with the sound side uppermost, should be insisted upon.

Anæsthesia may be induced in the semi-recumbent posture by a chloroform mixture or by chloroform. Ether in an open or semi-open inhaler, with or without oxygen, according to the patient's condition, should then be substituted, and administered for three or four minutes. The patient may now be safely placed in the upright posture and held so by an attendant during the operation. A light anæsthesia should be maintained and in many cases the coughing reflex allowed to persist.

A bad general appearance, with pallor, cyanosis, or a pinched look about the nose, is common in these cases, but is much less likely to occur in the upright posture.

If the lung of an etherized patient is opened during operation the use of the cautery near the wound is contra-indicated.

HEART DISEASE.

If a heart lesion is well compensated, no change from routine measures is necessary; but if dyspnœa, swollen ankles, pulmonary œdema, and other signs of broken compensation are present, the greatest caution is necessary.

As a rule, in all heart cases it is well to avoid those anæsthetics and methods which accelerate and excessively stimulate the respiration, as this reacts upon the circulation. Therefore nitrous oxide and close methods should be avoided. Ether should be avoided for inducing anæsthesia owing to the excitement and exaggerated breathing that it produces, but it may be used to advantage in sequence to chloroform or a chloroform mixture. The latter will usually be the best agents for inducing anæsthesia. They may be continued throughout the operation or followed by ether on a semi-open inhaler. Morphine and atropine are useful for slowing the respiration and keeping the respiratory passages clear of mucus. In myocarditis and in cases of fatty degeneration of the heart muscle, chloroform and its mixtures should be used with great caution. Yet they may be the best agents to use, especially for inducing anaesthesia. When another anaesthetic is being employed, the anaesthetist must be prepared to change to ether at any sign of failing circulation, and it may be well to do so as soon as anaesthesia is complete.

In cases with broken compensation anæsthesia should be carefully induced by chloroform or by a mixture in the position in which the patient can breathe most comfortably. According to the patient's condition anæsthesia may be continued by chloroform, by the mixture, or by ether on a semi-open inhaler.

Oxygen should be used in conjunction with the anæsthetic. The writers believe that a small preliminary dose of morphine and atropine and the A. C. E.-ether sequence, the ether being given on a semi-open inhaler with a constant stream of oxygen, is the best method.

A fairly profound anæsthesia is necessary to avoid disturbance of the respiration.

Hemorrhage.

Nitrous oxide should not be used in patients who are bleeding or exsanguinated, except in very small amounts and only for inducing anæsthesia, as it quickly causes asphyxia in such cases.

Ether is by all means the best agent to use. It should be given by the open or semi-open method and as sparingly as possible.

Chloroform should be avoided owing to the extreme ease with which circulatory depression results in cases of hemorrhage.

In certain operations, however, where it is important to avoid hemorrhage, as in cerebral surgery, it may be best to use chloroform from the first, provided the patient is in good condition.

Very small amounts of any anæsthetic are sufficient to control bleeding patients, and the use of morphine and atropine is entirely unnecessary. Oxygen given in conjunction with ether is a distinct advantage.

Obesity.

Obese patients are usually poor subjects for anæsthetics and often have weak hearts. As a rule, they do not do well under nitrous oxide or ether unless the latter be given in sequence to chloroform or a chloroform mixture.

The A. C. E.-ether sequence is probably the best method for use in obesity, or the administration of A. C. E. or anæsthol may be continued throughout.

Pericarditis.

As a rule, general anæsthesia is unnecessary for paracentesis of the pericardium. If general anæsthesia is necessary, the short anæsthesia resulting from a few inhalations of nitrous oxide, ethyl chloride, somnoforme, or ether would be sufficient.

If longer operations are necessary in such cases, a chloroform mixture of nitrous oxide and oxygen would be the best method to use.

The semi-recumbent posture should be used during the induction of anæsthesia.

PERITONITIS AND INTESTINAL OBSTRUCTION.

These cases are often difficult and dangerous to anæsthetize.

The rigidity of the abdominal wall in peritonitis interferes with the proper action of the diaphragm in respiration.

The regurgitation of fæcaloid matter, so common in intestinal obstruction, may cause suffocation by being inhaled during anæsthesia.

Furthermore, in hospital practice these cases are apt to come to operation heavily narcotized with morphine to relieve long-continued pain. If the anæsthetist is not aware of this, dangerous respiratory depression may occur during anæsthesia.

As a preliminary precaution the stomach of patients who are vomiting should be washed out. The washing should be done before the induction of anæsthesia, and the stomach tube may be left in during anæsthesia without in the least interfering with a good administration. This is a great safeguard against the inhalation of vomitus that is so dangerous in these cases.

Anæsthesia should be induced by a small amount of nitrous oxide or a chloroform mixture and maintained by ether on a semi-open inhaler.

The pulse should be carefully watched for circulatory depression.

PNEUMONIA.

Patients with pneumonia are unfit to inhale an anæsthetic. If a general anæsthetic were imperative, nitrous oxide and oxygen, or chloroform with oxygen, would probably be the choice.

Rectal anæsthesia has been used successfully in cases of unresolved pneumonia requiring operation.

PREGNANCY AND PARTURITION.

In parturition, chloroform is well taken, and it is said to be safer in pregnant women than in persons in ordinary health. Chloroform and ether are both suitable for relieving labor pains. If surgical anæsthesia is necessary, ether should be used. It may be preceded by nitrous oxide, A. C. E., or ethyl chloride.

Renal Disease.

The question as to whether ether or chloroform is the more irritating to the kidneys is much discussed. Both drugs, if inhaled for a considerable length of time, will cause albumin to appear in the urine.

It is probable that the kidney would be less affected by a careful administration of chloroform than by an indifferent administration of ether, and most writers incline to the belief that chloroform should be used. On the other hand, a skilful administration of ether by the close method, in which a very small amount of ether was used, would probably leave the kidneys in better condition than after chloroform.

If the disease is not advanced, no change of routine is necessary, except that as small a quantity as possible of the anæsthetic should be used and the period of anæsthesia made as short as possible.

In advanced Bright's disease, however, the administration of nitrous oxide and oxygen by a skilled anæsthetist will spare the kidneys as much as is possible, and not endanger the heart, should secondary changes in the heart muscle exist.

This has been successfully done many times in Edebohls' operation for decapsulating the kidneys.

Operations upon the kidney itself are apt to be attended by considerable shock and hemorrhage. The selection of the anæsthetic in these cases depends upon the patient's physical characteristics.

Shock.

In shock the period of anæsthesia should be made as short as possible by commencing the administration with the patient on the operating table, the surgeon being ready to operate at the moment anæsthesia is complete, and discontinuing the anæsthetic at the earliest possible time.

Suitable means for producing artificial heat should be at hand. Heaters and hot-water bottles should be applied, but they should be well wrapped up and not allowed to burn the patient.

Appropriate stimulants and oxygen should be at hand.

The anæsthetist should keep the surgeon informed of the rate and quality of the pulse, and, estimating the probable length of the operation, he should unhesitatingly warn the surgeon of impending danger.

When the pulse indicates approaching shock, the first essential is to lessen the depth of anæsthesia by discontinuing the administration, and giving fresh air or oxygen.

Hypodermic and rectal stimulation should be undertaken early. If one waits until the circulation is poor and then stimulates freely with hypodermic injections of strychnine, etc., the drugs may be imperfectly absorbed at first, and later have an excessive cumulative effect.

In suddenly developing shock the surgeon should be warned to cease operating, the anæsthetic should be withdrawn, the head lowered, and artificial heat produced by blankets and hot-water bottles.

Rectal stimulation is, as a rule, useful in combating shock, an enema consisting of two ounces each of brandy, coffee, and normal salt solution being an excellent one. (See the article on "Surgical Shock" in Vol. I.)

VII. THE RECOVERY PERIOD.

After-Effects of Anæsthetics.

The recovery period begins with the withdrawal of the anæsthetic and ends when the patient has fully regained consciousness.

As before stated, the anæsthetic should be removed as early as possible, the administration being so timed that, when the operation is over, the patient is well on the road to recovery.

Before the patient is transported from the operating table to bed, he should be carefully wrapped in blankets and protected against cold and draughts. It is especially important to protect the chest and to keep the feet warm. Moving of patients should be done with as little jelting as possible, in order not to provoke vomiting.

Chloroformed patients should be allowed to recover or nearly so upon the operating table before they are moved. When they are lifted the head should be kept low to avoid syncope.

In hospitals, with plenty of assistants and wheeled trucks, the transportation of patients is a simple matter. In private houses, however, patients should be carried in the arms of one or more persons. If one man is lifting the patient, the hand of the arm that encircles the trunk should grasp the axilla of the patient in such a way that the latter's head will be supported on the lifter's arm. The other arm grasps the knees and thus the patient can be easily carried.

The bed should be properly warmed and the recovery room well aired. A responsible person should make certain, however, that no hot-water bottles or heaters remain in bed with the patient. In certain cases it may be well to place the patient between warm blankets and to support the foot of the bed upon a chair in order to lower the head. Patients do better if allowed one low pillow for the head, a second one being used to support one shoulder or to keep the patient in the lateral posture. As before insisted upon, it is important to keep the head on the side from the moment anæsthesia is complete until the coughing and swallowing reflexes return.

Vomiting may occur on the operating table or not until the patient is in bed. A recovering patient should always be carefully watched and assisted to vomit until recovery is complete. On this account posture in bed is of great importance. If the respiratory passages are clear the dorsal position with the head on the side, and one shoulder slightly supported, is sufficient. If, however, there is an excess of mucus and saliva or a constant faecaloid regurgitation, the lateral or even the semi-prone posture will be necessary in order to provide adequate opportunity of escape. During the act of vomiting the jaw should not be held forward, as this deprives the larynx of the protection of the epiglottis; nor should the jaw be pressed backward, as this impedes respiration; the patient should be allowed to vomit by himself, the only interference being to insure an adequate access of fresh air by pulling the cheeks away from the teeth by the finger or thumb introduced into the mouth.

Covering the face with hot towels, then drying it thoroughly and powdering it, are of great help in the case of patients recovering from anæsthesia. These measures, besides tending to remove the odor of the anæsthetic, improve the appearance and have a remarkably stimulating and refreshing effect.

As a rule, patients recover better if the room is darkened and kept noiseless and they are allowed to sleep. All conversation should be avoided at this time, as patients who are apparently unconscious can often hear and understand and are correspondingly disturbed.

Men who are abusive and violent and women who are hysterical during recovery should be restrained only just enough to keep them from injuring themselves or others, and they should be spoken to as little as possible, as argument and persuasion are of little or no avail.

Morphine should not be given until consciousness is fully regained. If given too soon it delays recovery and prevents the proper clearing of the respiratory passages by vomiting and coughing. It may also depress the respiration to an alarming degree, as its action is intensified by ether or chloroform.

Post-anæsthetic sickness consists of varying degrees of headache, nausea, vomiting, and thirst.

As a rule, after nitrous oxide, ethyl chloride, or somnoforme, there is little or no sickness.

After ether there often is sickness which may be severe, although not so severe as that which sometimes results from chloroform.

After chloroform, sickness is less common than after ether, although when it does occur it is apt to be more severe.

Much can be done by a proper preparation to avoid post-anæsthetic sickness. Careful dieting and purging before operation are important. A proper administration of the anæsthetic will also tend to prevent sickness. Sickness after ether may be due to swallowing ether-charged mucus and saliva or to overdosing: after chloroform sickness is generally due to an uneven anæsthesia or to overdosing. These things will not happen in a proper administration.

Many things have been tried for the relief of nausea and vomiting.

The free administration of water by mouth, after anæsthesia, works well in some cases.

Washing out the stomach before and after anæsthesia may be tried and in many cases is of distinct help. It should be done with warm water while the patient is unconscious.

Among the drugs that have been tried with varying success are:

Chloretone; vinegar inhaled from a gauze sponge; aromatic spirits of ammonia; sodium bicarbonate; cerium oxalate; sips of hot water with or without sodium bicarbonate; sips of hot coffee; sips of cold champagne may be tried.

Generally speaking, the best way of avoiding post-anæsthetic sickness is as follows:

A good preparation of the patient for anæsthesia;

A skilful administration of the anæsthetic;

Allowing the patient to "sleep off" the anæsthetic in an absolutely quiet, darkened room, with plenty of fresh air,—possibly re-enforced by oxygen.

Thirst may be treated by allowing sips of the above-mentioned liquids and by the administration of salt solution by rectum. Eight ounces every three hours, or smaller doses more frequently, may be injected.

Respiratory disturbances of different kinds sometimes follow anæsthesia, particularly ether anæsthesia. These are termed generically "ether pneumonia," which may be:

1. A diffuse bronchitis, which is usually an aggravation of an already existing simple bronchitis;

2. A broncho-pneumonia, usually due to the inhalation of mucus, saliva, vomitus, or the regurgitation of fæcaloid material;

3. A true lobar pneumonia, usually due to sweating and subsequent chilling during an operation performed on a patient whose resistance is already lowered by shock, hemorrhage, or sepsis;

4. A pneumonia of embolic origin, usually occurring after operation. Such a case could be only indirectly due to the anæsthetic.

The prophylaxis of "ether pneumonia" is important.

The mouth, nose, and throat should be perfectly clean at the time of operation. The teeth should be well brushed and a mouth wash and gargle should be used before the anæsthetic is administered.

A skilful administration, in which no excess of mucus and saliva is developed, and in which a small quantity of the anæsthetic is used, is the best safeguard against an ether pneumonia. The use of morphine and atropine in this connection has already been spoken of. Respiratory complications are more apt to follow an administration of ether by the open or semi-open method than one by the close method.

All apparatus should be surgically clean before it is used.

It is very important to protect the patient carefully against draughts and cold before, during, and after the anaesthesia.

A proper position in bed during recovery, to facilitate proper drainage and the coughing up of mucus and saliva, is also important.

The treatment of a developed "ether pneumonia" is the regular medical treatment of bronchitis, broncho- or lobar pneumonia.

Renal complications following anaesthetics have already been spoken of (page 226). Transient albuminuria with casts is not uncommon after prolonged inhalation of ether or chloroform. Hæmaturia and urinary suppression have sometimes followed ether and chloroform, usually after severe operations.

Glycosuria sometimes follows the administration of nitrous oxide, and, according to some observers, it may manifest itself after the use of chloroform. Cases of aciduria (acetonuria) are reported to have followed the inhalation of ether or chloroform, usually in children. Inasmuch as such cases have been observed to develop without either operation or anaesthesia, it is hard to determine to just what extent they are dependent upon anaesthesia. In a series of cases analyzed by Brackett * he says: "In one of the fatal cases, and in five of the milder ones, the symptoms came on without operation or even anæsthesia." He concludes that "anaesthesia alone does not bring on the condition, or at least not in a serious form."

The prophylaxis of renal complications consists of:

1. A proper preparation of the patient without excessive deprivation of liquids before anæsthesia.
2. A skilful administration of the anæsthetic, as small a quantity as possible of the agent being used.
3. The administration of liquids by mouth during or immediately following anæsthesia.

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* Boston Med. and Surg. Journal, July 7th, 1904.

THE PRODUCTION OF LOCAL ANAESTHESIA FOR SURGICAL PURPOSES.

By JAMES F. MITCHELL, M.D., Washington, D. C.

General Considerations.

Although local anæsthesia in its modern sense owes its first application to an American surgeon (Halsted), yet its development and extended use in major surgery have been left to Europeans. Whether lack of patience, time, and inclination, or ignorance of modern advanced methods in technique, is responsible for the pessimistic regard in which it is held, certainly it is deserving of more consideration than it now receives as a substitute for general narcosis in a host of minor and major surgical operations. The history of the search for a local means of rendering surgical procedures painless dates back to remotest antiquity, and on looking through the medical literature of past centuries we find one method after another proposed, tested, and then cast aside. Earliest among these was local compression by means of a tourniquet or a pad. Then came the application of cold and, following this, efforts to produce local insensibility by means of various substances applied to the surface of the body, or by carrying them through the unbroken skin. All sorts of drugs were thus tried and sooner or later abandoned. A new field was opened in 1853 by the introduction of the hypodermic syringe by Wood, who immediately suggested its use for the injection of morphia into nerve trunks for the relief of neuralgia. The introduction of cocain in 1884 made possible modern local anæsthesia, and its immediate adoption and practical use by Halsted stamp him as the father of its development. Halsted's work was soon followed by the papers of Corning in 1885 and following years. Corning's work, overlooked for years alike in this country and abroad, was later repeated by European investigators. Since then the development of local methods has been marked by important observations and discoveries. Most striking of these have been: The use of dilute solutions (Reclus and Schleich) and massive infiltrations (Matas); the injection of nerve trunks (Crile, Cushing, Matas); the addition of adrenalin to solutions (Elsburg, Barker); the use of intraspinal injection (Bier); and the introduction of new and less toxic drugs.

For practical purposes it is possible to produce local anæsthesia by: (1) Pressure, (2) cold, or (3) the application or injection of drugs.

(1) *Pressure.*—Pressure on a sensory nerve trunk will in time render it anæsthetic so that surgical procedures may be painlessly carried out in the

region of its distribution. Constriction of a limb was hailed as a boon in pre-anæsthetic days for the relief of pain during amputations, and with this idea in view various forms of tourniquets with pressure pads were tried and discarded. The uncertainty of the anæsthesia and the length of time necessary to produce it, the actual pain of the pressure itself and the danger of gangrene and motor paralysis render this method unsafe and impracticable. It has only the narrowest application in slight operations on the fingers and toes.

(2) *Cold.*—The anæsthetic properties of cold have long been recognized, and the crude method of placing ice about the field of operation has been of no small value. The substitution of ether, drop by drop or in the form of a spray, was an advance; and at the present time the *ethyl-chloride spray* represents the perfected process. It acts as a terminal anæsthetic. Its application is very simple. The tube is held at some distance from the skin and the small stream of ethyl chloride allowed to play on the point of proposed incision. In a few seconds the part appears frozen and is thoroughly anæsthetic. The process of freezing is painful and later there is also considerable pain as the circulation is restored. Gangrene of the skin may result from extensive or prolonged freezing. Ethyl chloride applied for a sufficiently long time to nerve trunks causes a complete blocking of conduction of sensation; but it is questionable whether many patients would stand the pain which must be endured before this point is reached. The anæsthesia is superficial and it is impossible to differentiate frozen tissues; hence its practical application is confined to small operations such as punctures, or the incision of furuncles and small abscesses. Even here the use of cocain is more comfortable and more effectual. Cold and pressure, as such, have then a very narrow field of usefulness, but as aids to the production of anæsthesia by means of drugs they are valuable.

(3) *Application or Injection of Drugs.*—There are now known a great number of substances which, applied to mucous surfaces or injected into tissues, render them anæsthetic. The first of these to be used was cocain, and, speaking generally, it is still the best. The action of these substances, the methods of application, the aids to their local action, and the prevention of their toxic effects, with the study of the surgical procedures for which they can be utilized, will be considered in the following pages.*

ANÆSTHETIZING SUBSTANCES.

(1) *Cocain.*—Cocain, like all substances used to produce local anæsthesia, is a protoplasmic poison. In the early days of its use many cases of severe and even fatal poisoning were reported, occasioned by the concentrated solu-

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* The most comprehensive and thorough work on the subject of local anæsthesia is by H. Braun, of Leipsic (1905). In this work will be found a complete résumé of the literature, with instructive diagrams and illustrations and minute details of the operative procedures. The writer has drawn freely upon it in the preparation of this article.

tions then in vogue. Cocain forms with protoplasm an unstable combination, which disintegrates slowly, when the tissues are able to return to their previous condition and function. The various tissues differ in the readiness with which they enter into this combination, the brain and central nervous system being most susceptible,—hence in cocain poisoning the chief symptoms are referable to the central nervous system. Sensory nerves are acted upon more readily than are motor. The mildest symptom of poisoning is slight dizziness; and from this there are all grades leading to collapse, convulsions, and death. As poisoning is due to absorption from the local site of application we should take every precaution to prevent this. Cocain which has exerted its anæsthetic action is held in combination, and cannot be absorbed into the circulation, nor can it be recovered from the tissues as cocain. It is the excess over the amount which the tissues can thus take up to which poisoning is due. The toxic dose varies with the method of administration. Intravenously, it is stated to be 2 mgm. ($\frac{3}{100}$ grain). Subcutaneously, the maximal dose is given as 50 mgm. ($\frac{3}{4}$ grain). If, however, dilute solutions are used, or absorption is prevented or delayed, by interruption of the blood stream by means of a tourniquet or by adrenalin, much larger amounts can be safely administered. Poisoning is rare when the precautions mentioned are observed. Solutions of cocain are more or less unstable chemically, and are weakened or destroyed by prolonged or repeated boiling. The methods of preparation of solutions will be given later.

Numerous substances have been recommended as substitutes for cocain. Most important among these are tropococain, eucain, akoin, nirvanin, and stovain.

(2) *Tropococain.*—Tropococain forms more stable solutions than cocain, and these solutions stand boiling without decomposition. It is also less toxic than cocain, but the anæsthesia produced by it is less lasting. A dose of 200 mgm. in weak solutions (one-half to one per cent) is harmless.

(3) *Eucain B.*—Eucain B in solution also stands boiling. Very weak solutions are effective. The duration of its anæsthesia is less than is that produced by cocain. It is one-third or one-fourth as toxic as cocain, and this fact, together with its cheapness, makes it one of the best of substitutes; it is by many preferred to cocain. It is used in solutions of the same strength.

(4) *Akoin.*—Akoin produces anæsthesia more slowly than does cocain in solutions of the same strength, but the anæsthesia lasts longer. Its toxicity is less than that of cocain; but on account of its cumulative action, it is actually more dangerous. Its maximal dose is given as 25 mgm. In strong solutions (above one-half to one per cent) it causes grave tissue injuries. The difficulty in preparing solutions, and their instability, make the drug of little use in practice.

(5) *Stovain.*—Stovain is chiefly useful for spinal anæsthesia. It can be

sterilized by boiling. It is less powerful as a local anæsthetic and less lasting in its action than cocain. Its maximal dose is 200 mgm. The ordinary strength of solution used is one-half to one per cent.

(6) *Magnesium Sulphate.*—Magnesium sulphate has been recently suggested by Meltzer for the production of local and general anæsthesia by intraspinal injection. It has been shown that 60 mgm. per kilogram body weight will produce a complete motor and sensory paralysis. After-effects are constant and troublesome. A very small dose proves fatal intravenously and large intraspinal doses produce death by paralysis of respiration. It should, therefore, be used with the greatest caution and does not seem to possess any advantages over cocain.

Aids to Anæsthesia.

The three great aids to the production of local anæsthesia and the prevention of toxic effects are: (1) Constriction with a bandage to obstruct the circulation; (2) the application of cold; and (3) the addition of the adrenal preparations to anæsthetizing solutions.

(1) *Constriction.*—An anæsthetizing substance acts much more powerfully if the blood stream is interrupted, because it is then retained at the point of injection. More of the substance enters into local protoplasmic combination, and there is less to be absorbed when circulation is restored. The parts remain anæsthetic as long as constriction is maintained, and thus the duration of the anæsthesia can be greatly prolonged.

(2) *Cooling* the injected area by means of the ethyl-chloride spray acts in a similar manner, by constricting the blood-vessels, decreasing absorption, increasing local action of the drug, and increasing the duration of anæsthesia.

(3) *Adrenalin* (epinephrin or suprarenalin) was first prepared in 1901 in pure form. It is a peripheral vaso-constrictor. Solutions of the strength of 1:1,000,000 will produce a local ischæmia. Added to anæsthetizing solutions it thus has the same effect as constriction or cold. It is the most valuable aid to local anæsthesia and the best prophylactic against poisoning, and is also of great assistance in providing a more or less bloodless field of operation. It, like cocain, is destroyed in the tissues after its action is exerted. The maximal dose is fifteen drops of the 1:1,000 solution, which is the ordinary commercial strength.

Preparation of Solutions.

It was noted by Halsted and his followers that water forcibly injected into the skin would render it anæsthetic for a short time. This anæsthesia is due to distention alone, and has been designated "anæsthesia dolorosa," because it is anæsthesia obtained at the expense of pain. The pain, in this instance, is due to the difference in osmotic pressure between water and the fluid of the body tissues. Fluids which are isotonic with blood cause no pain when injected into the skin, while the injection of fluids of greater or less osmotic pressure than the blood is painful. Hence it is important to have the solution used for obtaining local anæsthesia isotonic with the blood. Isotonic aqueous solutions of cocain or its substitutes alone would contain a prohibitively high percentage of the anæsthetizing substance. The deficiency in the anæsthetic in solutions of appropriate drug content is, therefore, made up by the addition of sodium chloride. For practical purposes, spinal anæsthesia being left out of consideration for the moment, the two following solutions, as recommended by Braun, are sufficient:

A. Cocain hydrochlorate	0.1 gm. (1.5 grain)
Physiological salt solution ($\frac{9}{10}$%)	100 c.c.
Adrenalin (1: 1,000)	5 drops
B. Cocain hydrochlorate	0.05 gm. (0.75 grain)
Physiological salt solution	5 c.c.
Adrenalin (1: 1,000)	10 drops

Formula A thus represents a 1: 1,000 cocain solution, and may be further diluted with normal salt solution where large amounts are to be injected, as in the massive infiltrations of Matas, or in extensive or prolonged operations according to the method of Schleich. The solutions recommended by Schleich, containing morphia in addition to cocain and salt, are not isotonic with the tissue fluids and are, therefore, not to be recommended. Solution A, as such, or diluted, is much to be preferred. Morphia is much better given before the operation, or afterward in case of restlessness.

Formula B is a one-per-cent solution of cocain, and this likewise may be diluted as desired with normal salt. The total amount of cocain in the formulæ given above may all be used with safety in a single operation.

Eucain B may be prepared in the same dilutions, and larger amounts of these can be used at one time. Eucain solutions can be boiled and will remain fairly unchanged. Cocain solutions, on the other hand, should be freshly prepared. The ideal method is that used by Braun, who has prepared tablets containing the above proportions of cocain and suprarenalin. The tablets are sterilized by dry heat at 80° C. for an hour on three successive days, and are to be dissolved in sterile normal salt solution immediately before the operation. I have in the last year, through Parke, Davis & Co., been able to have these tablets duplicated, and have found them most satisfactory. There are also on the market many tablets containing cocain alone or in combination with adrenalin, and I can recommend the following method of sterilization as having proven most satisfactory. The cocain tablets (or, in their absence, a measured amount of cocain powder) are placed in small vials, each containing a single tablet. The vials are plugged with cotton, the mouth of each via protected with a hood of gauze. These are sterilized by dry heat, as above, and may be kept ready for use. Immediately before operation a tablet is dissolved in the proper amount of sterile normal salt solution, and the adrenalin added drop by drop to the required amount.

For small operations, where the amount to be used is not large, it may be more convenient to have the solution ready prepared, and for such cases it is best sterilized in an autoclave for twenty minutes at 115° to 120° C. Cocain solutions stand this sterilization very well. I have found it very convenient to have small bottles prepared. Each bottle is loosely corked, and over the cork is a large hood of cotton and gauze secured by a string about the neck of the bottle. The bottles are sterilized in the autoclave and, after removing, the cork can be pushed in tight by seizing it through the hood, thus having the bottle tightly closed with a sterile cork. Solutions prepared in this way may be kept for some time, but cannot be relied upon for extensive operations. A small amount of cocain solution may be boiled once, just before use, without deterioration, in case of emergency.

METHODS OF APPLICATION.

(1) *Surface Application.*—Anæsthesia can be produced by applying cocain in strong solutions to mucous membranes by means of the spray or the mop. Its use in this way is confined to special branches of surgery: Laryngology, ophthalmology, etc. Solutions of ten-per-cent concentration are used.

(2) *Infiltration.*—This method, popularized by Reclus and Schleich, has been modified by Matas and Braun. According to Schleich, the skin is to be anæsthetized by producing a distention wheal, being a physical as well as a chemical method. After this the tissues are injected as encountered, the object of the procedure being to bring the solution in contact with all parts of the field of operation, special attention being paid to nerves, blood-vessels, and connective-tissue bundles. Matas accomplishes the same purpose by forcing into the parts large amounts of a very dilute solution, by means of air pressure, with a specially devised instrument. Braun aims so to distribute a weak solution in the subcutaneous tissue as to anæsthetize the nerves before they reach the skin, thus bringing about a more extensive anæsthesia and making unnecessary the production of a wheal along the line of incision. In the deeper parts his object is, by using several points of injection, to distribute the solution about the nerves supplying the field of operation. The advantages of this method are that a wider area is anæsthetized, permitting better retraction and exposure, and that the anæsthesia is of greater duration. Braun's idea is that, by waiting a few minutes from the time of injection, we may have the whole field of operation anæsthetic before the operation is started.

(3) *Nerve Blocking.*—Nerve blocking may be accomplished by endoneural, perineural, or spinal injection.

Perineural Injection.—Perineural injection was first performed by Halsted on the inferior dental nerve for the painless extraction of teeth. If an anæsthetizing solution is introduced about a nerve trunk, the nerve in a certain length of time is acted upon by the anæsthetizing substance, so that it no longer transmits sensations. Naturally, the time required and the completeness of the block depend upon the size of the nerve trunk, the thickness of its sheath, and the strength of the anæsthetizing solution used. Sheathless nerves within the spinal canal are most readily affected: and in the subcutaneous tissue, just before the nerves undergo their final division, they offer a good field for the application of the method. For large nerve trunks, such as the ulnar, a solution of cocain one-half to one per cent in salt solution, with the addition of adrenalin, is most satisfactory, while in the subcutaneous tissue a one-tenth or two-tenths-per-cent solution suffices.

Endoneural Injection.—Endoneural injection owes its introduction and development to Crile, Cushing, and Matas, and by its intelligent application the possibilities of local anæsthesia are enormously increased. Superficial nerves, such as the ulnar at the elbow, may be reached without incision; but ordinarily the nerve must be first exposed. The needle is then thrust directly into its substance, and the solution (one-half to one-per-cent cocain or eucain) injected until the nerve appears swollen and œdematous. Almost instantly the whole area of its distribution is rendered anæsthetic and ready for the painless execution of any surgical procedure. The nerve conduction is perfectly blocked, and undoubtedly there is less shock in dividing a nerve which has been so injected, even though the operation is performed under general narcosis. (Cushing.)

Indications and Contra-indications.

The large number of new methods of producing general narcosis speaks for the want of a perfectly safe one, and it cannot be denied that even when their use is in the most experienced hands there still remains a certain justified dread of them all. That local anæsthesia is not more generally employed can be ascribed partly to lack of time and patience on the part of operators and partly to their inexperience in its use. The old danger from strong solutions in the early days of cocain has not been forgotten, and this memory is partly responsible for neglect of the local method. With the modern use of weak solutions and the aids to local anæsthesia, this objection can no longer be urged. Local anæsthesia offers little or no danger to life. While no absolute rule can be laid down, it may well be said that where the field of operation can be made painless and the operation itself can be as well performed under local as under general anæsthesia, the former should be the method of choice. Many minor procedures, such as exploratory punctures, the opening of furuncles, etc., ordinarily done without anæsthesia, can be carried out more thoroughly and with vastly more comfort to the patient with the aid of local anæsthesia. In conditions where skilled assistance is not at hand, operations otherwise impossible can be thus accomplished. With patients in a state of greatly lowered vitality, general anæsthesia in itself may be enough to turn the scale downward. Experience shows that local anæsthesia does not have the same depressing effect as a general narcotic, and therefore haste in the operation is not so essential. Where general anæsthesia is absolutely contra-indicated, operations may be performed under local anæsthesia with no apparent change in the patient's general condition. If it is impossible to obtain perfect local anæsthesia, great benefit can be derived from Cushing's "morphia-cocain-chloroform" combination, by tiding over with a few whiffs of chloroform the painful stages, without reaching the point of general narcosis. We have almost without exception observed that general narcosis thus added to local anæsthesia is not only well borne, but that the patient yields more readily to the general anæsthetic; and where complete narcosis is reached, it is obtained with a smaller amount of the anæsthetic. An advantage often of importance is the avoidance of the after-effects of general narcosis, and the strain on sutures consequent to vomiting. Earlier administration of nourishment is possible and undoubtedly the danger of post-operative pneumonia and renal insufficiency is lessened. In children and in very neurotic individuals local anæsthesia is, as a rule, impracticable; and in operations for extensive malignant growths or where complete muscular relaxation is essential, it is absolutely contra-indicated.

General Preparations and Technique.

The general preparation of the patient in extensive operations should be practically the same as for narcosis, except that a glass of milk or a cup of coffee (when not contra-indicated by the nature of the operation) may be taken a few hours beforehand. The patient should be in a quiet frame of mind, and an excellent procedure is to give a small dose of morphia ($\frac{1}{8}$ to $\frac{1}{6}$ gr. hypodermically) an hour before the operation. The table should be arranged with a comfortable pad, and the utmost quiet and order should be maintained in the room. All instruments and preparations should be as much as possible hidden from the patient's sight. It is of the utmost importance that the operator have the confidence of his patient. Of great assistance is the so-called "moral-anæsthetist," whose duty is to record the pulse and to entertain the patient, and thus to distract his attention from the operation itself. An operator unaccustomed to an accomplished assistant of this type cannot realize his true value. An occasional sip of water, a whiff of aromatic ammonia, or a reassuring remark may tide over an important moment in the accomplishment of some operative procedure. The importance of psychical pain should not be underestimated. There can be no exact criterion for the estimation of pain. It undoubtedly differs in individuals and varies with race, culture, intelligence, and mental condition. The success of local anæsthesia in Germany may be in part ascribed to the phlegmatic nature of the subjects. Intelligent persons give less expression to pain than do the weak and ignorant; old persons less than the young; country people less than dwellers in the cities. Fear of pain or its expectation undoubtedly increases its intensity. Sensibility to pain differs in different organs, and in the skin itself some parts are much more sensitive than others. Subcutaneous tissue has no intrinsic sensation, but carries the nerves to the skin. Muscles and tendons likewise are sensitive only in their sheaths and connective-tissue lamellæ. Periosteum is exquisitely sensitive, but bone has little sensation. Joint capsules and synovial membranes are very sensitive, while cartilage, like bone, has little sensation. In general, all organs innervated by spinal nerves are sensitive, while those supplied by the sympathetic system are not. Success in operating depends in great measure on knowledge of the location and distribution of sensory nerve trunks. Each tissue must be cautiously approached, and special attention should be paid to connective-tissue bundles, blood-vessels, and other probable courses of nerve fibres. The accidental clamping, traction, or division of an unanæsthetized nerve trunk in the early stages of an operation may render its completion under local anæsthesia impossible. Haste is, therefore, to be avoided. Great care should be given to the placing of retractors and to the force exerted upon them, traction on unanæsthetized tissues being avoided. Sponging of the wound should be accomplished with the same end in view. An awkward or rough assistant may interfere greatly with the comfort of the operation. Success increases with experience. In my first two typhoid perforations I felt obliged to resort to general anæsthesia for the completion of the operation. In later cases I have been able to carry out every detail under local anæsthesia—an ability due entirely to experience and consequent acquaintance with the painful procedures which may be avoided. Much depends upon the character of the operator himself. Not every good surgeon can work successfully with local anæsthesia. Often his whole style of operating must be changed. As Matas puts it, "where impatient spectators are looking for brilliant and rapid work, local anæsthesia can never take a strong hold." Operations necessarily consume more time, and great patience and self-control are required. Good syringes and needles are a necessity. I have found two sizes of syringes sufficient, and have no fault to find with the ordinary steel needles. The syringe most frequently used is the ordinary hypodermic syringe, with glass barrel and asbestos packing, holding about 3 c.c. The other is like that ordinarily used for the administration of antitoxin, likewise with asbestos packing, and holding 10 c.c. With the larger pressure apparatus used by Matas I have had no experience, but where a large amount of solution is to be injected it will undoubtedly save time. The syringes mentioned may be boiled in plain water without soda. A valuable point in the care of syringes is to see that they are thoroughly dried after use, and then a few drops of castor oil drawn into the barrel will keep the packing tight and the syringe in good working condition. Needles of several sizes should be at hand, and it is wise to be sure that their lumens are patent and the syringe in good working order before beginning the operation.

The general principles of the different methods have been given. The selection of a method for a particular case depends upon the individual operation and the preference of the operator. The best results are often obtained by a combination of methods. Infiltration according to Schleich, diffusion or perineural injection of Braun, may in one operation be combined with the injection of nerve trunks according to Crile, Cushing, and Matas, or all of these may be supplemented by the administration of small amounts of a general anæsthetic.

Special Application.

Skin.—The line of incision should be exactly determined upon before beginning the injection. Upon a careful and complete anæsthesia of the skin may depend the success of the operation. According to the method of Schleich, the skin is independently (Figs. 88 and 89) anæsthetized. A point on the line of incision, preferably at one end, is selected, and the skin pinched up between the thumb and finger. Into this the needle is quickly thrust just deep enough to bury its bevelled point. The solution is then slowly injected till a wheal is formed, when the needle is pushed along, keeping its point behind the forward edge of the wheal. The subsequent introductions of the needle are made in the anæsthetic wheal, so that the first needle prick may be the only painful procedure. Braun holds the independent anæsthetizing of the skin to be un-

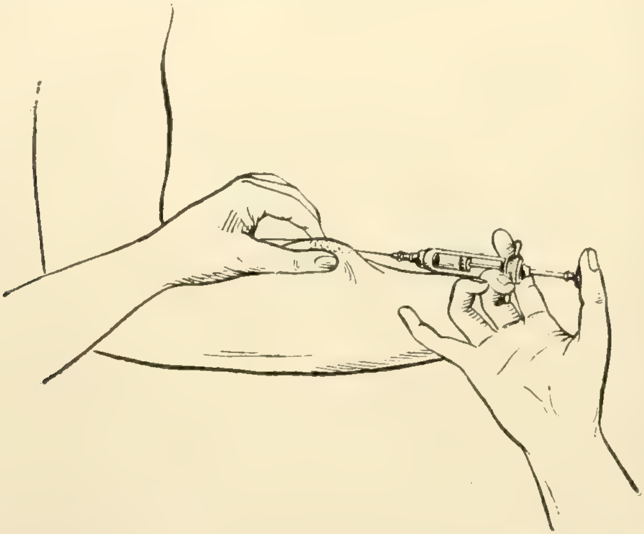


FIG. 88.—Anæsthetization of the Line of Skin Incision by the Production of a Wheal. (After Reclus.)

necessary. According to his method the line of incision is marked by the formation of a small wheal at either end, or at several points in a circular incision.

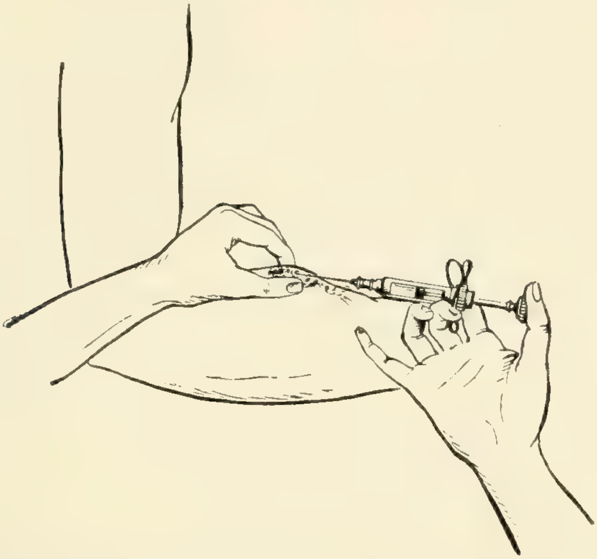


Fig. 89.—Showing Subsequent Injections Made within the Border of the Wheal Produced in Fig. 88. (After Reclus.)

(Fig. 90.) Through this wheal the needle is thrust directly into the subcutaneous tissue, and by introducing the needle in different directions the fluid is distributed through a wide subcutaneous area, thus blocking the nerves before they reach the skin. Through the same points the deeper tissues can be injected in a similar manner. (Fig. 91.) This deep injection should be made slowly in order to allow the solution gradually to diffuse itself, as rapid distention causes pain by pressure on unanæsthetized nerves. The pressure apparatus of Matas does away with the necessity of removing the needle in order to refill the syringe.

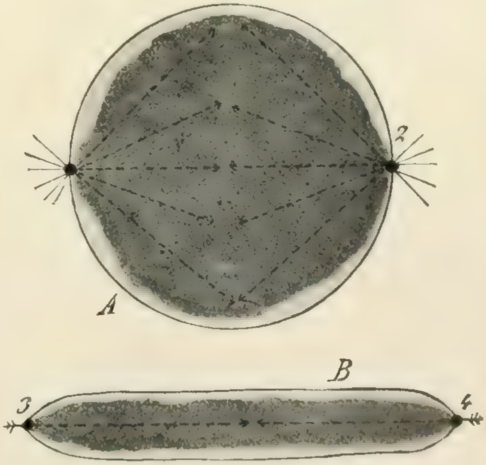


Fig. 90.—Anæsthetization of Skin by Subcutaneous Injection, Showing the Wide Area of Distribution through Two Injection Points. (After Braun.)

Head.—Much of the difficulty previously encountered in the application of local anæsthesia to the surgery of the head and neck, because of inability to confine the anæsthetizing fluid, has been overcome by the introduction of adrenalin. With an intimate knowledge of the nerve supply and special attention to the regions of nerve trunks, many operations previously requiring general narcosis may be done with cocain, as is well illustrated by a reported case of Matas, in which he partially excised both upper maxillæ and the entire hard palate under regional anæsthesia. The nerve supply of the *scalp* (Fig. 92), with that of the underlying fascia and periosteum, comes from below, so that large areas may be made anæsthetic by injecting subcutaneous cross strips below the proposed seat of operation, thus blocking the nerve supply. A cross strip of subcutaneous injection with 1:1,000 cocain with adrenalin above the supraorbital ridge (Fig. 93) renders anæsthetic the whole central portion of the forehead. Sebaceous cysts and other tumors can be removed in this way, or with ease by simple or massive infiltration, or by circular injection blocking the nerve supply on all sides. In the same way scalp wounds can be repaired and even the cranial vault and the brain itself can be reached; for the bone, dura, and brain cortex have no intrinsic innervation.

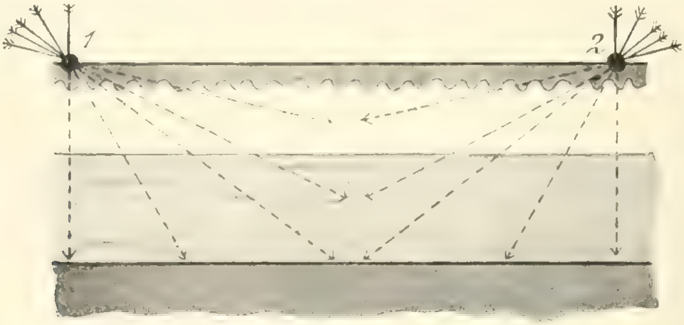


FIG. 91.—Injection of the Deeper Structures through the Same Points as in Fig. 90. The arrows represent the needle passing in various directions through skin, subcutaneous tissue, and muscle, to the periosteum. (After Braun.)

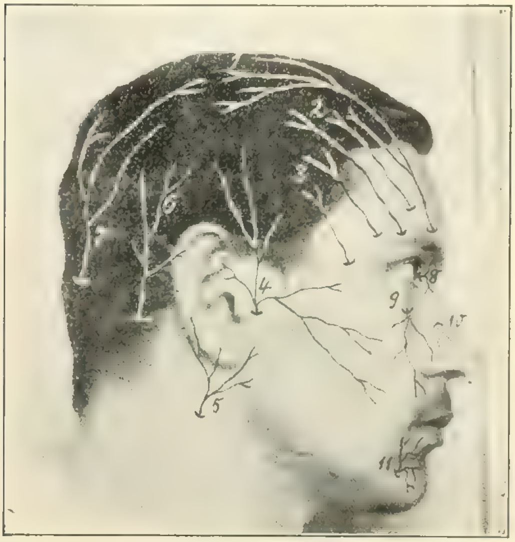


FIG. 92.—Nerve Supply of Face and Scalp from the Cervical Plexus and Trigeminal Nerve. 1, N. frontalis; 2, n. supraorbitalis; 3. n. zygomatico-temporalis (trigeminus II); 4, n. auriculo-temporalis (trigeminus III); 5, n. auricularis magnus; 6, n. occipitalis minor; 7, n. occipitalis major; 8, n. supra- and intra-trochlearis; 9, n. infraorbitalis; 10, ramus nasalis ext. nervi ethmoidalis; 11, n. mentalis. (After Braun.)

Plastic operations about the ear, mouth, and face offer a satisfactory field for the various local methods. Minute details of these operations are given by Braun. Carcinomata of the lips can be readily removed by simple infiltration, and I have repeatedly excised their respective glandular areas in the same way; but, where an indefinite or extensive dissection is to be made, narcosis is indicated.

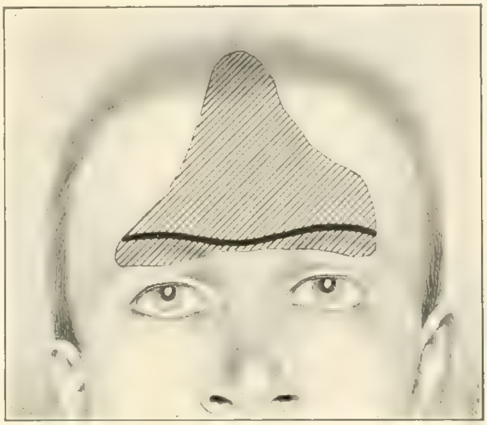


Fig. 93.—Showing the Area of Anæsthesia Produced by a Cross Strip of Subcutaneous Injection above the Supraorbital Ridge, Blocking the Nerve Supply from Below. (After Braun.)

Fractures of the lower jaw can be painlessly wired by carrying the injection down to the periosteum on each side of the fracture. The inferior dental nerve may be injected in its canal. Drilling the bone causes no pain.

Mastoid operations are best left to general narcosis, although they have been done by the infiltration method.

The use of local anæsthetics in work upon the eye, ear, nose and throat is well known, but it does not concern the general surgeon, and the extensive application of the method in dentistry will not be considered here.

Neck.—The exit of the branches of the cervical plexus at the posterior border of the sterno-mastoid muscle offers an excellent opportunity for blocking superficial sensation in the anterior triangle. (Fig. 94.) Individual or small groups of lymph nodes, cysts, and lipomata can be removed, and most of the ligations of vessels in the neck can be easily accomplished by infiltration or by deep circumscribing injections. Deeper cysts or nodes offer greater difficulties, but I have been able to do a complete excision of all lymph nodes with division of the sterno-mastoid and omo-hyoid muscles. This was accomplished by infiltrating the skin along the posterior border of the sterno-mastoid and exposing the cervical plexus. This was blocked with one-per-cent cocain, the skin incision completed and the dissection proceeded with. When the deeper parts were reached the tissues likely to carry sensory nerves were injected before division, and when nerve trunks were exposed they were likewise blocked. The operation was done upon

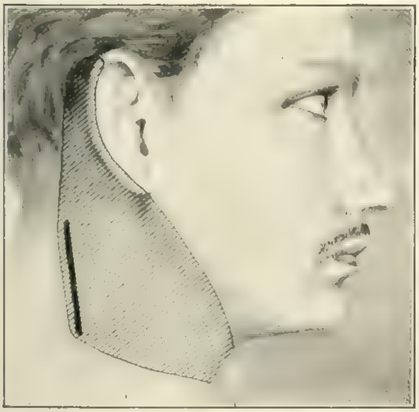


Fig. 94.—Area of Anæsthesia Produced by Blocking the Cervical Plexus at the Posterior Border of the Sterno-mastoid Muscle. (After Braun.)

a young colored girl (a poor subject), but was completed with practically no complaint of pain.

The larynx as a special field for local anæsthesia has been exploited by Crile, who has shown that the dangerous reflex-carrying power of the superior laryngeal nerve can be entirely abolished by the application of cocain to the nerve or to its endings in the laryngeal mucosa. The superior laryngeal nerve, carrying sensation and reflexes, lends itself readily to perineural blocking at the tip of the posterior cornu of the hyoid bone. Operations upon the larynx or its complete excision can be satisfactorily carried out under local infiltration when this nerve is blocked.

Tracheotomy in adults is by choice an operation for local methods. It is easily and satisfactorily done by infiltration.

Goitre.—It has been a matter of considerable dispute as to whether the removal of hypertrophied or diseased thyroid glands be included rather in the domain of narcosis or in that of local anæsthesia. The objection advanced against the local method has been that there was no procedure by which the whole field could be rendered anæsthetic. Granting the objection, I believe that it ought not to exclude the local method; for those surgeons who have had the greatest experience, as Kocher, Roux and others situated in the goitre zone, prefer local anæsthesia. Although my own experience has been limited to a few cases I have never found it necessary or desirable to resort to general anæsthesia. Certainly it would seem that the operation is fraught with greater dangers when narcosis is induced. I have had occasion to witness two such operations in which the patient died on the table, while in a large number of cases in which the local method was used I have never seen a mishap. More especially do these considerations apply in the case of exophthalmic goitre.

The operative procedure required is one in which experience counts for a great deal, and where special care and patience are necessary. The transverse incision can be painlessly carried through skin and subcutaneous tissue by endermal or subcutaneous injection of the weakest solutions, but nowhere is careful work in the early stages of the operation more essential. The large blood-vessels upon the coverings of the gland should be carefully handled and their perivascular tissue infiltrated before clamping and dividing the vessels. The operation can then be carried out by Schleich's method, infiltrating layer by layer and paying especial attention to nerves, connective-tissue bundles, and blood-vessels. Retraction is to be restricted to the least possible amount, and the use of too small an incision is to be avoided. The delivery of deep-lying lobes may be difficult, but by careful dissection and a sufficiently large incision it can be accomplished without causing great pain. The most trying part of the operation is the ligation of the superior and inferior thyroid vessels. The division of the isthmus I have never found troublesome or painful. Thyroid tissue is without sensation. It has been demonstrated by Kocher that the danger of injuring the recurrent nerve is decreased by the local method; for by requiring the patient to speak occasionally the operator can readily detect compression of this nerve by the change in phonation. In Kocher's second thousand cases reported in 1900 there were only four deaths. The greatest single factor contributing to this low mortality rate was undoubtedly the substitution of local for general anæsthesia.

Thorax and Breast.—The applications of local anæsthesia are limited in this region.

Wiring of the clavicle can be readily done under the principles which apply to fracture of the lower jaw.

Puncture of the pleura (or pericardium) should always be done with the aid of a local anæsthetic. The operation can be rendered absolutely painless by injecting the skin at the point of the puncture, and then infiltrating the whole line of puncture before introducing the aspirating needle. As only a small amount of the anæsthetic is required, a strong solution (one-per-cent cocain) is recommended as acting more thoroughly and quickly.

Resection of a rib in thoracotomy offers an easy task for the local method. The skin is endermically injected and incised, and then the subcutaneous tissue and muscle are infiltrated with a weak solution. The periosteum is anæsthetized with a stronger solution (one-half-per-cent cocain) and is then incised and reflected. The cutting of the rib is painless. The parietal layer of pleura is sensitive and requires a separate injection. The visceral pleura is devoid of sensation. The operation may be painlessly carried out by subcutaneous injection through a point at either end of the proposed incision, the needle at the same time being carried down to the periosteum. After waiting a few minutes the whole field of operation is thus rendered anæsthetic. The advantage of the local method is evident in these cases, where there is often such grave danger in narcosis.

The breast lends itself badly to local methods. Small, superficial and freely movable benign tumors can be removed by infiltration, and entire removal of the breast has been reported. The presence of a malignant tumor is an absolute contra-indication to local anæsthesia.

Upper Extremity.—The extensive application of local methods to the upper extremity has been well demonstrated by Crile and Matas. Crile completed a shoulder-girdle amputation by injecting the brachial plexus as it leaves the scaleni in the supraclavicular fossa. Blocking of the plexus in this way renders possible operations on any portion of the arm and amputation at any level. The large nerve trunks in the arm offer a most attractive field for the endoneural and perineural methods. (Fig. 95.) By exposing and blocking by endoneural injection the musculo-spiral, median, or ulnar nerve, any desired area can be anæsthetized. (Fig. 96.)

The median nerve is easily accessible at the wrist for perineural injection.

The needle is introduced at the ulnar side of the tendon of the palmaris longus (Fig. 95) and passed beneath the tendon diagonally toward the radius a distance

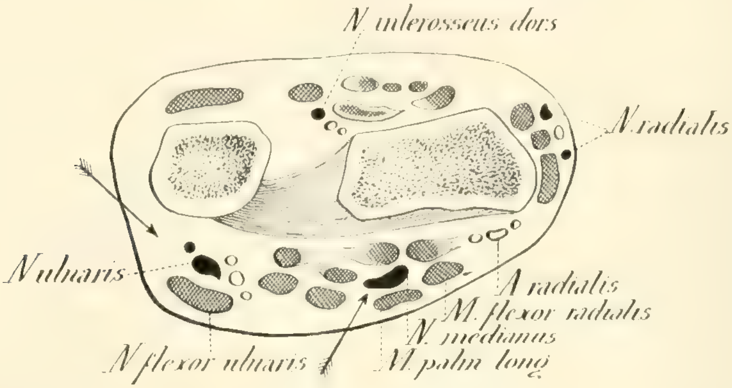


FIG. 95.—Cross-section of Forearm (5 cm. above the wrist). The arrows indicate the direction of the needle in reaching the median and ulnar nerves for perineural injection. (After Braun.)

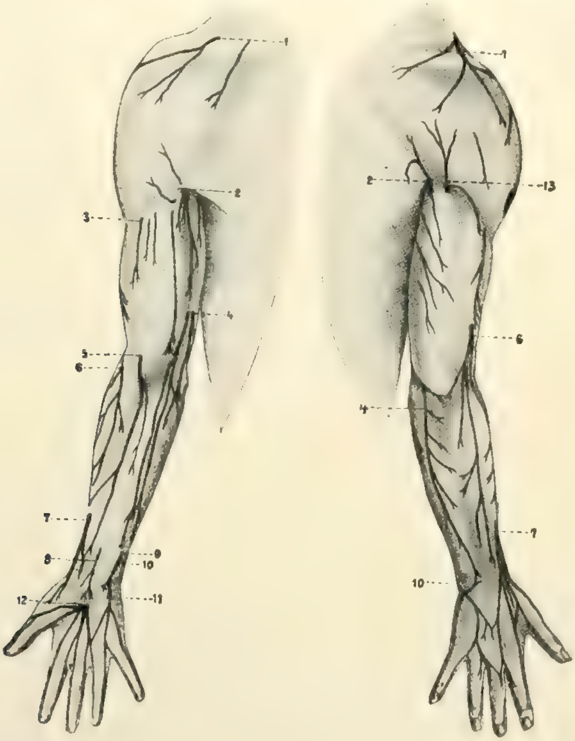


FIG. 96.—Distribution of the Nerves of the Upper Extremity to the Skin Anteriorly and Posteriorly. 1, Supraclaviculares; 2, cutaneus brachii medialis; 3, cutaneus brachii anterior; 4, cutaneus antebr. med.; 5, cutaneus antebr. lateralis; 6, cutaneus antebr. dorsalis; 7, radialis superficialis; 8, ramus palmaris n. mediani; 9, ramus palmaris n. ulnaris; 10, ramus dorsalis n. ulnaris; 11, n. ulnaris; 12, n. medianus; 13, cutaneus brachii lateralis. (After Braun.)

of from one to two centimetres. The solution is thus injected about the nerve beneath the tendon of the flexor carpi radialis. A strong solution (cocain one-half to one per cent) is used, and the anæsthesia should appear in from ten to twenty minutes. Above this point the median nerve is not accessible except by exposure.

The radial nerve can be reached just above the styloid process of the radius by a cross strip of subcutaneous injection. This, in addition to the perineural injection of the median nerve, anæsthetizes the whole radial surface of the hand.

The ulnar nerve can be reached for perineural injection about 5 cm. (2 inches) above the wrist. The needle is inserted between the ulna and the tendon of the flexor carpi ulnaris (Fig. 95), and the solution (one-half to one per cent cocain) injected at a depth of 1½ to 2 cm. (⅘ inch). A cross strip of subcutaneous injection may also be necessary to anæsthetize the dorsal branch of the ulnar. By extending this cross strip above the head of the radius, the radial nerve is also blocked and the whole of the dorsum of the hand anæsthetized.

Individual fingers are perhaps the most frequent site for the application of local anæsthesia. Each finger is supplied by two anterior and two posterior nerves. (Fig. 97.) These can be reached through two points of injection at the base of the finger toward the dorsal border. A rubber tube is first tied about the base of the finger and then a small amount of a strong solution (one-half to one per cent cocain) is injected about the anterior and posterior nerves. In five minutes the whole finger is anæsthetized for amputation or for the treatment of felons or infections. By paying attention to the course of the nerves between the metacarpal bones, the bases of the fingers and the metacarpals can be made anæsthetic. By the combination of local injection with nerve-blocking, amputation at any level of the arm is possible.

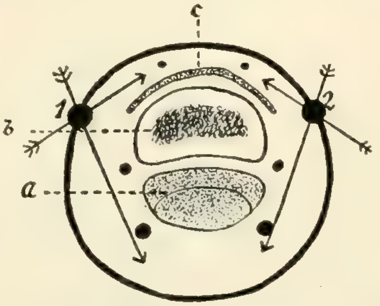


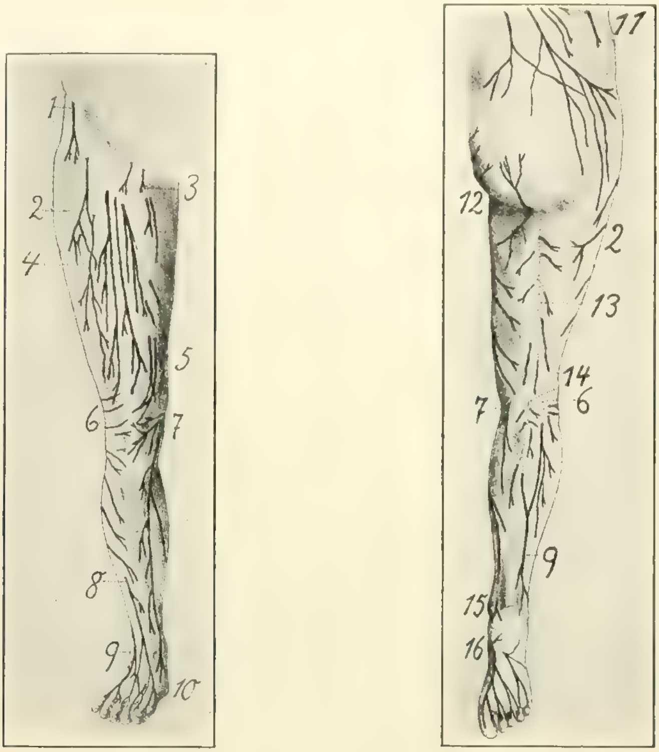
Fig. 97.—Cross-section through Base of Finger. Showing the direction of the needle in anæsthetizing the whole finger. *a*, Flexor tendons; *b*, bone; *c*, extensor tendons. The nerves are indicated by black dots according to the size of the individual trunks. (After Braun.)

Inflammation and infection of the olecranon bursa may be approached by infiltrating around the bursa, carrying the injection to the periosteum. In the same way fractures of the olecranon offer an easy field for the local method. The same principles apply here as for wiring a fractured clavicle or lower jaw.

Axilla.—The axilla, except for the removal of small benign tumors or individual lymph nodes, or for the opening of abscesses, cannot be included in the realm of local anæsthesia. Extensive dissections for malignant conditions necessitate the administration of a general anæsthetic.

Lower Extremity.—On account of the complex nerve supply of the buttocks and the highest part of the thigh, local methods in these regions are unsatisfactory. (Fig. 98.) In the lower part of the thigh and in the leg and foot all operations, no matter what their extent, can be painlessly performed by the open endoneural cocainization of the sciatic and the long saphenous, or of the anterior crural and external cutaneous nerves. The posterior tibial nerve can be reached for perineural injection at the internal malleolus by inserting the needle 1 cm. ($\frac{2}{5}$ inch) from the median border of the tendo Achillis, passing it directly forward to the posterior surface of the tibia, and then withdrawing slightly and injecting the solution. (Fig. 99.)

Individual toes are anæsthetized just as are fingers, by two lateral injections at the basal phalanx. Ingrowing toenails can thus be painlessly treated. By carrying the injection between the metacarpals, deeper anæsthesia may be obtained for the amputation of toes, or the excision of metacarpals, as in the operation for hallux valgus. Amputation of the lower extremity at any level is a satisfactory procedure under the local methods.



FRONT. REAR.

Fig. 98.—Superficial Distribution of Nerves of Leg Anteriorly and Posteriorly. 1, Ilio-hypogastricus; 2, cutaneus fem. lateralis; 3, lumbo-inguinalis; 4, cutaneus fem. anterior; 5, obturatorius; 6, cutaneus suræ lateralis; 7, saphena; 8, peronæus superficialis; 9, suralis; 10, peronæus profundus; 11, clunium superiores; 12, clunium inferiores; 13, cutaneus fem. posterior; 14, cutaneus suræ medialis; 15, r. calcanei n. tibialis; 16, tibialis. (After Braun.)

Fractures of the patella can be painlessly wired or the prepatellar bursa excised by simple infiltration, carrying the injection to the periosteum.

The knee joint can be explored by a simple procedure. A wheal is raised by endermal injection, and through this point the line of puncture is cocainized to the synovial membrane. A large needle is introduced, and what fluid the joint contains is evacuated. The joint is then filled with 1:1,000 cocain with adrenalin. This is withdrawn in ten minutes, and the joint is found to be insensitive and may be explored with instruments, irrigated, foreign bodies removed, etc. Small joints lying in a field which can be rendered anæsthetic need no separate treatment.

Genito-Urinary System.—The bladder and urethra are especially adapted to the surface application of local anæsthetics, cocain, eucain, or akoin being equally serviceable. The many cases of cocain poisoning which have been reported in this field are due to the use of unnecessarily strong solutions injected into the bladder. The addition of adrenalin is valuable. For the urethra one-per-cent solutions of cocain are sufficient. The bladder, after being thoroughly washed, may be rendered insensitive by filling it with 0.1-per-cent cocain (plus adrenalin) and allowing this to remain for fifteen to twenty minutes before withdrawing it. The solution should be cold. The bladder can then be painlessly explored with the cystoscope or sound, and stones may be crushed. For suprapubic cystotomy the bladder should be first treated in this way, and the incision may then readily be made under infiltration anæsthesia.

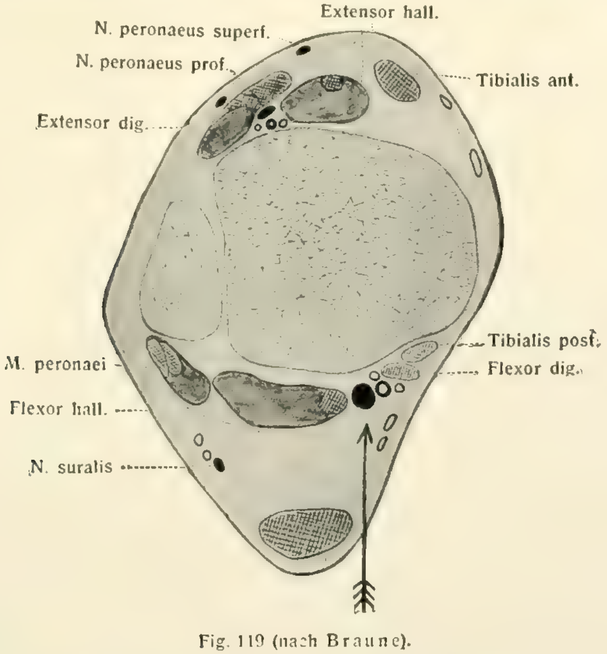


FIG. 99.—Cross-section through Leg just Above Ankle, Showing Direction of Needle for Perineural Injection of Posterior Tibial Nerve. (After Braun.)

Circumcision in older children or adults can be done by direct infiltration of the line of incision, especial attention being paid to the frænum. (Figs. 100, 101, and 102.) The mucous membrane may be first anæsthetized by filling the prepuce with one-per-cent cocain and waiting a few minutes. Krogius applies the blocking method by injecting subcutaneously a ring about the base of the penis. Braun injects 0.5-per-cent cocain about the coronary sulcus. In adults general narcosis is never indicated in this operation.

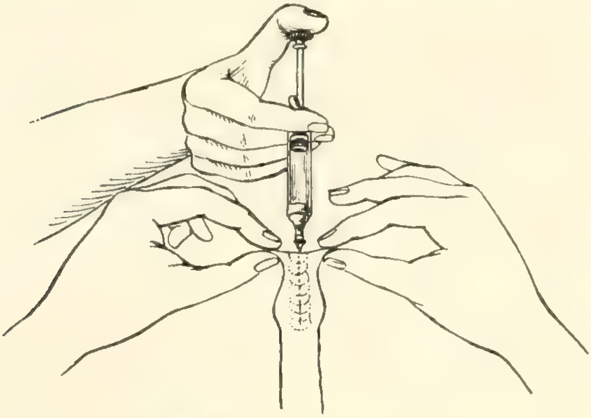


Fig. 100.—Anæsthetization of Prepuce in Circumcision. (After Reclus.)

External urethrotomy is readily done by infiltration, the mucosa having been previously anæsthetized by surface application.

Internal urethrotomy cannot be rendered painless by local methods, but gradual dilatation can be successfully accomplished.

Prostatectomy has been performed by Tinker by means of infiltration.

Narcosis is practically never necessary for operations upon the scrotum and its contents. A combination of infiltration for the skin and subcutaneous tissue, with injection of the cord just outside the external ring, enables one to carry out painlessly the procedure of ligation or castration, or the radical cure of hydrocele. The high varicocele operation can be performed by a modification of Cushing's technique for hernia, to be described later.

Rectal Surgery.—In surgery of the rectum and perineum, spinal anæsthesia finds its most satisfactory and safest application, yet by the local methods practically any of the ordinary procedures can be accomplished. The sphincter ani may be anæsthetized by injecting it thoroughly with one-per-cent cocain plus adrenalin. It can then be painlessly stretched for examination or treatment of the mucous membrane. By a circumscribing injection carried well up along the

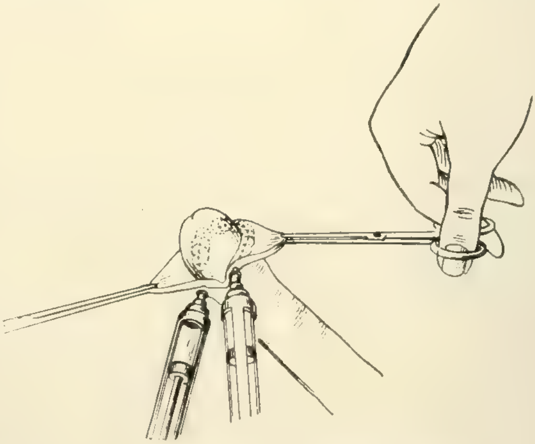


Fig. 101.—Anæsthetization of Base of Prepuce in Circumcision. (After Reclus.)

rectum, guided by a finger within, the whole lower rectum becomes available for operation. (Figs. 103 and 104.) Fistulæ, if small, may be excised by the use of simple injection. Hemorrhoids, if small, may be removed in the same way, and complete excision, or the ligature or cautery operation, can be accomplished by means of the deep circumscribing injection. For extensive hemorrhoidal operations, large fistulæ, or ischio-rectal abscesses, spinal anæsthesia would seem to be the method of choice.

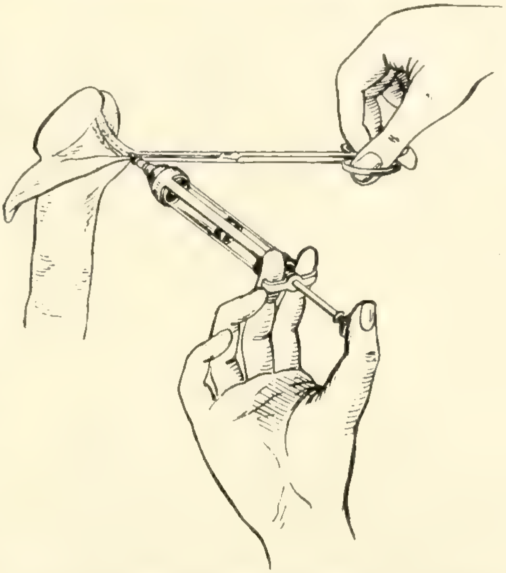


FIG. 102.—Showing Separate Injection of Frænum in Circumcision. (After Reclus.)

Abdomen. — The possibilities and scope of local anæsthesia in abdominal work depend to a great extent upon the individual operator, his experience and knowledge of the sensitive regions, and the manner in which they are to be avoided. In the clinic of the late Professor Mikulicz fully one-third of the operations were done under local anæsthesia. For operations involving only the abdominal parietes, general principles apply as in other parts of the body. Incisions in the middle line can be made by layer infiltration or by subcutaneous injection. Incisions through the rectus muscle can be painlessly made by infiltrating layer by layer with very weak solutions. The transverse bands of the rectus muscle carry nerves and blood-vessels and need special attention. The McBurney or gridiron incision is easily completed by infiltrating layer by layer and retracting carefully. The ilio-hypogastric and ilio-inguinal nerves are usually exposed in the internal oblique muscle, or between it and the transversalis. They can be injected when seen, or, if not, these muscles should be broadly infiltrated in order to secure good retraction. The region of the kidney can be reached in the same way. In any abdominal incision when

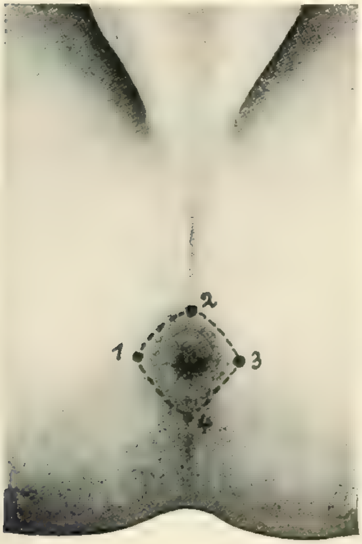


FIG. 103.—Anæsthetization of Anal and Rectal Regions. The four dots represent the injection points. (After Braun.)

the preperitoneal tissue is reached, it should be injected with a strong solution (one-per-cent cocain) before incising.

The peritoneum has been shown by the work of Lennander to vary greatly in its sensibility in different regions. The parietal peritoneum is exquisitely sensitive, while the visceral layer is devoid of sensation. All organs innervated by the sympathetic system are insensitive. Therefore, pain attributed to the abdominal viscera during manipulations can be explained as being due in all cases to some disturbance of the parietal layer either by direct contact or by indirect traction or pressure. Incision or crushing of any part of the gastro-intestinal tract is not accompanied by pain so long as there is no dragging on the parietal peritoneum directly or through the mesentery. The liver or gall bladder can be painlessly incised with the cautery or with cutting instruments, provided this traction is avoided. Large portions of the omentum can be painlessly removed. It can readily be seen, then, that an especially careful technique is necessary in all abdominal procedures, and that the parietal peritoneum is to be avoided. The placing of retractors and the force of retraction should be carefully regulated. In introducing or removing gauze pads, care should be taken not to rub them over the parietal peritoneum, and, in handling the abdominal viscera, dragging on their parietal attachment should be avoided. In inflammatory conditions the parietal peritoneum becomes more sensitive, but the visceral layer remains free from sensation. It is evident that in operations involving organs lying in apposition to the anterior abdominal wall, local anæsthesia is especially indicated.

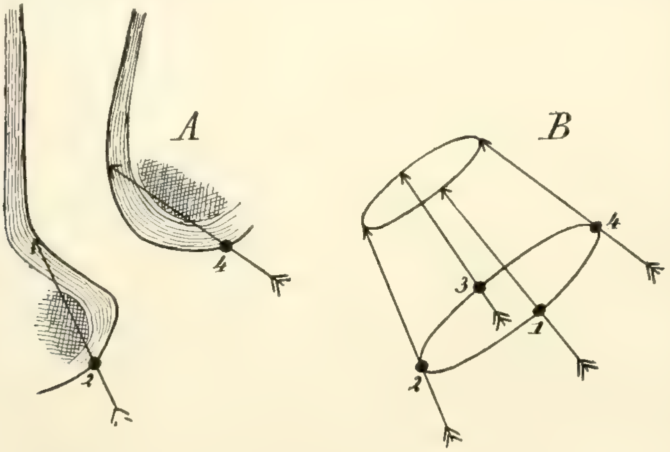


Fig. 104.—Sagittal Section of Rectum, Showing the Direction of the Needle in Anæsthetizing the Rectum. *A*, Cross-section, in a vertical plane, of the anus and rectum; in the diagram *B* are shown the four points (1, 2, 3, 4) where the needle should be inserted. (After Braun.)

Gastrostomy for œsophageal stricture or foreign bodies can practically always be done by the aid of local anæsthesia. In the absence of adhesions gastroenterostomy is also practicable.

The gall bladder can be drained, as in acute typhoidal cholecystitis; but, where the ducts also are to be examined, narcosis is indicated.

The intestines are available for suture or for the establishment or closure of an artificial anus or fistula.

A most important procedure for which local anæsthesia is especially indicated is abdominal exploration for intestinal perforation in typhoid fever. "Hesitation over the propriety of subjecting a patient already suffering from the effects of a serious disease, to the additional risks of general anæsthesia, has perhaps more than any other factor been the occasion heretofore of delayed surgical intervention, when acute abdominal symptoms have supervened during the course of typhoid fever. It is not to be doubted that the calamities of anæsthesia are especially prone to follow upon its prolonged administration to patients during such febrile states." (Cushing.) This danger is practically obliterated by the use of a local anæsthetic, and at the same time the necessity for a hurried exploration is done away with. The knowledge that a cocain exploration is without danger, must lead one to explore, without hesitation, many cases where a positive diagnosis would be demanded before subjecting these patients to general narcosis. Typhoid patients, as a rule, are ideal subjects for local anæsthesia. The detailed technique is that of any abdominal operation, and the same care and experience are necessary.

Hernia, in all its external forms, offers a fruitful field for local anæsthesia; but with strangulation I feel that the indication for local methods is absolute, as also with individuals of advanced years, who would otherwise be refused operation. After some experience, ether and chloroform no longer remain the anæsthetics of choice, even where there are no contra-indications to their administration. In my own work, with a considerable number of hernia cases, during the past four years, fully nine-tenths have been done under local anæsthesia, and it is only in the rarest cases that a general anæsthetic has been administered. I formerly believed general anæsthesia to be a necessity for recurrent cases, but recent experience has convinced me that these offer little more difficulty than the primary hernia operations. Post-operative herniæ with wide separation of muscles, on the other hand, usually necessitate general anæsthesia.

Umbilical herniæ, unless very large, are easily repaired. The layer method of Schleich, or the circumscribing blocking injection of Braun, aided by a separate injection of the neck of the sac and preperitoneal tissue, will suffice. (Fig. 105.) I have found the layer method most satisfactory, and have had little difficulty in completing the operation, even in very fat individuals, where the excision of large portions of omentum was necessary. It is in these cases especially that local anæsthesia is most to be desired.

Femoral herniæ offer greater difficulty for the local method, but injection by layers with weak solutions is usually satisfactory.

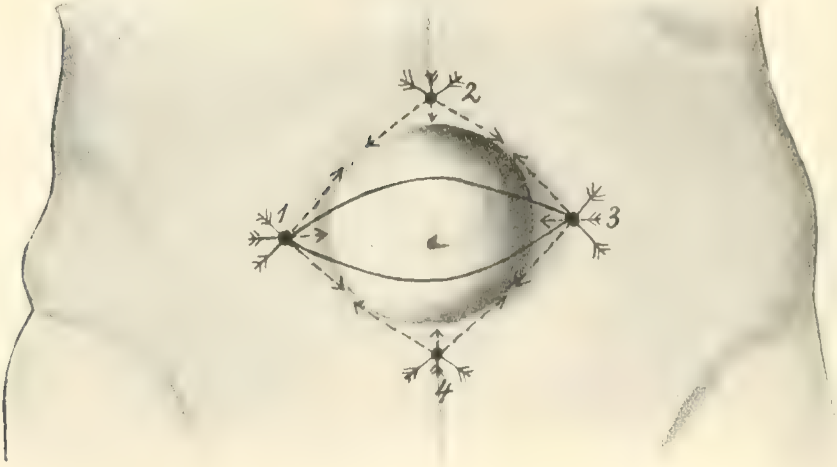


Fig. 105.—Scheme of Injection in Large Umbilical Hernia. The figures indicate the injection points; the arrows and dotted lines show the directions of the needle, and the solid lines the incision. This represents a characteristic example of the circumscribing blocking method of Braun. (After Braun.)

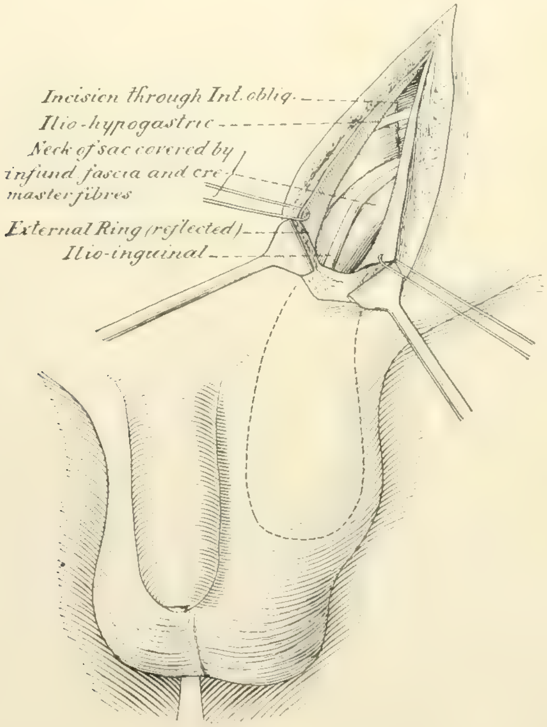

Incision through Int. obliq.
Ilio-hypogastric
Neck of sac covered by infund. fascia and cremaster fibres
External Ring (reflected)
Ilio-inguinal

Fig. 106.—Sketch Showing Usual Situation of Nerves as Exposed after Division and Reflection of the Aponeurosis of External Oblique Muscle. (After Cushing.)

Inguinal Hernia.—Cushing's method is without doubt the most satisfactory for all inguinal hernias, whether simple or strangulated, and is one of the most striking applications of regional or blocking anaesthesia. Braun's objection, that it does not apply for strangulated hernias, because it necessitates the opening of the sac before inspecting the peritoneal cavity, does not hold. It has always been my habit where gangrene or perforation within the sac was suspected, to open the peritoneal cavity above the neck, and in this I have experienced no great difficulty. The method renders insensitive the field of operation, and the operator is then without restriction as to the type of radical cure to be performed. The method will be given in detail as described by Cushing: "The skin in the line of proposed incision is infiltrated with Schleich's cocain solution (1:1,000), and the incision may be immediately made through the linear wheal thus produced. . . . If, however, throughout its whole length, this incision is carried down to the aponeurosis, unanæsthetized fibres of the ilio-hypogastric will be encountered in the superficial fat at the lower angle, together with one or two large veins, division of which is painful, so that anæsthetization of the panniculus layer would here be necessary. A much better method is to carry the incision only at the upper angle down to the aponeurosis, which is then

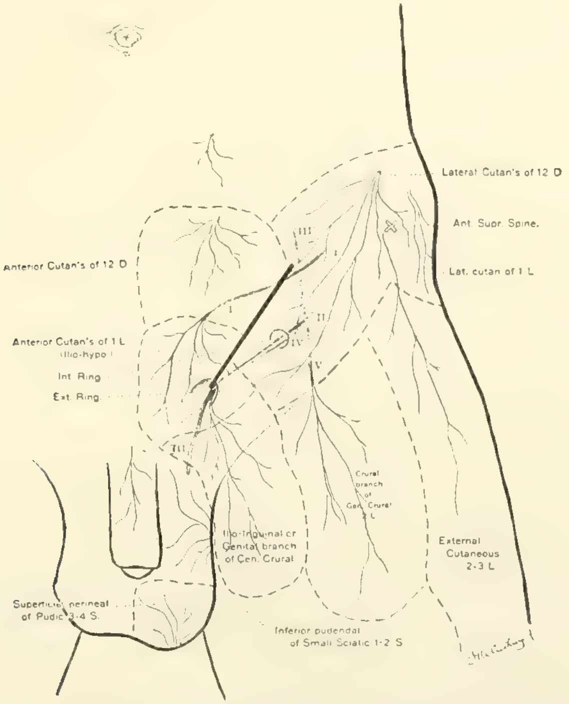


FIG. 107.—Relations of the Inguino-Scrotal Nerves to the Hernia Incision. (From *Annals of Surgery*, vol. xxxi., 1900: "Observations upon the Neural Anatomy of the Inguinal Region Relative to the Performance of Herniotomy under Local Anaesthesia," by Harvey Cushing, M.D.) *I*, Ilio-hypogastric; *II*, ilio-inguinal; *III*, genito-crural; *IV*, genital branch; *V*, crural branch.

opened in line of fibres from the external ring and the ilio-hypogastric and inguinal nerves immediately cocainized with a one-per-cent solution as they are thus exposed. After this procedure the lower angle of the incision may be painlessly carried down to the external ring, and the remaining intercolumnar fibers of the aponeurotic insertion divided. Reflection of the pillars of the ring then gives the view shown in the accompanying sketch. (Fig. 106.) There is, under ordinary circumstances, no further need of the anæsthetic, as we are working in an area freed from all sensation. . . . The remainder of the operation, the exposure of the sac at its neck, and the closure of the peritoneal opening, the excision of the fundus of the sac, division of the cord, and castration—if deemed advisable in senile cases—may now be done practically without pain. Occasionally, however, some stray fibres of the genito-crural may be encountered about the neck of the sac. . . . The closure of the parietes by any of the more commonly employed methods may now be painlessly accomplished. . . . Tightening the deep sutures in closing the wound may elicit a dull sensation of pain which the patient usually describes as an uncomfortable sensation of 'pressure.' . . . The subcuticular silver suture, used in closing the skin, . . . may be placed without pain." Cushing's sketch (Fig. 107) shows the usual distribution of the inguino-scrotal nerves, which are subject to great variation—not enough, however, materially to interfere with the operation as described above. I have found that the addition of adrenalin to the anæsthetizing solution is of the greatest assistance. Another useful addition to Cushing's technique is the thorough cocainization of the neck of the sac at an early stage, by injecting about it and the cord a few drops of one-per-cent cocain with adrenalin.

Spinal Anæsthesia.

The idea of injecting substances within the spinal canal for the production of anæsthesia was first suggested by Leonard Corning, of New York, in 1885. There followed some experimental work of Europeans, but Corning's observations remained unnoticed. The perfection of the technique of lumbar puncture by Quincke aroused new interest, and in 1899 appeared the first work of Bier, to whom we owe the introduction and development of the method for surgical purposes. The great number of failures, serious after-effects, and deaths reported caused the method to fall into bad repute. The improvements in technique have considerably changed this state of affairs; but in this country it has never become generally popular, although it is used extensively by certain surgeons. Dangerous after-effects have been lessened by the addition of adrenalin to the anæsthetizing fluid and by the substitution of less toxic drugs for cocain. The anæsthetic acts directly on the sheathless nerves of the cauda equina and on the nerve roots, not upon the conduction tracts of the cord itself. Both sensory and motor roots are affected, but the former to a much greater extent. Anæsthesia begins within five to ten minutes after injection and lasts from half an hour to two hours, but with the addition of adrenalin its duration is increased. It commences about the genitalia and extends to the legs, abdomen, and sometimes to the arms and head. Below the navel it is reasonably certain and of long enough duration for ordinary operations. Its progressive action is due to the gradual upward diffusion of the anæsthetic, becoming less as the drug is more and more diluted by the cerebro-spinal fluid. Naturally, the most intense anæsthesia is obtained at the point where the anæsthetic is most concentrated; hence, by injecting at different levels or by elevating the pelvis, the anæsthesia can be more or less regulated. On account of danger of injury to the cord, the point of injection is limited to the lumbar spaces. The height to which the anæsthesia ascends depends upon: (*a*) the dose of the drug used, (*b*) the amount of fluid injected and the rapidity of injection, and (*c*) the position of the patient, *i.e.*, the relative level of the pelvis. The serious after-effects depend upon the amount of the drug which reaches the medulla; therefore, the danger is greater when high anæsthesia is sought by elevation of the pelvis or by large doses or forced injection of the drug.

Unpleasant and *dangerous symptoms* may appear immediately or during or after anæsthesia. Milder symptoms have been noted by some operators in fifty per cent of cases when cocain was used. These are the symptoms of poisoning —nausea, vomiting, sweating, tremor, etc. In most cases they soon pass off, but may go on to collapse and death. After-effects were just as often noted—headache, vomiting, weakness, and loss of appetite, lasting for days. In many cases there have been chills and rise of temperature. The frequency of after-effects has been lessened by the introduction of adrenalin. According to Braun the action of adrenalin is to cause the blood-vessels about the cauda equina to contract and thus create a negative pressure, bringing about a downward current of cerebro-spinal fluid. Many of the symptoms after spinal anæsthesia are due to irritation of the meninges, causing a reactive inflammation with great increase in the cerebro-spinal fluid, thus explaining the headache, etc. It is a meningitis. Braun ascribes this to the difference in osmotic pressure between cerebro-spinal fluid and the solution injected, and gives in support of this view the observation that such symptoms are rarely seen when the anæsthetic is dissolved in cerebro-spinal fluid before injection. It does not seem likely that a technique will ever be devised which will entirely banish unpleasant symptoms, for these are sometimes observed after simple lumbar puncture.

A certain number of *failures* to obtain anæsthesia have been reported. These cannot be attributed to an idiosyncrasy against cocain or other drugs, for in many instances a second attempt has succeeded after the first absolutely failed. The proper explanation of probably all failures is that either there is some abnormality of the spinal canal, or more frequently that the technique is faulty or the anæsthetic impure or inactive. All of the ordinary local anæsthetics have been used for the production of spinal anæsthesia.

Cocain has been most extensively applied. The dose, as generally agreed upon, for obtaining anæsthesia (1) of the lower extremities is 15 mgm., (2) up to the sternum 20 mgm., and (3) of the upper extremities 50 mgm. Cocain alone is no longer used, but it is always accompanied by adrenalin. For this purpose tablets have been devised. Braun's tablets contain cocain 10 mgm., suprarenalin $\frac{1}{10}$ mgm., and salt 90 mgm. They can be sterilized by the fractional method and kept ready for use.* It is claimed by others that the salt is unnecessary, but such tablets afford the most convenient form in which to handle the cocain and adrenalin.

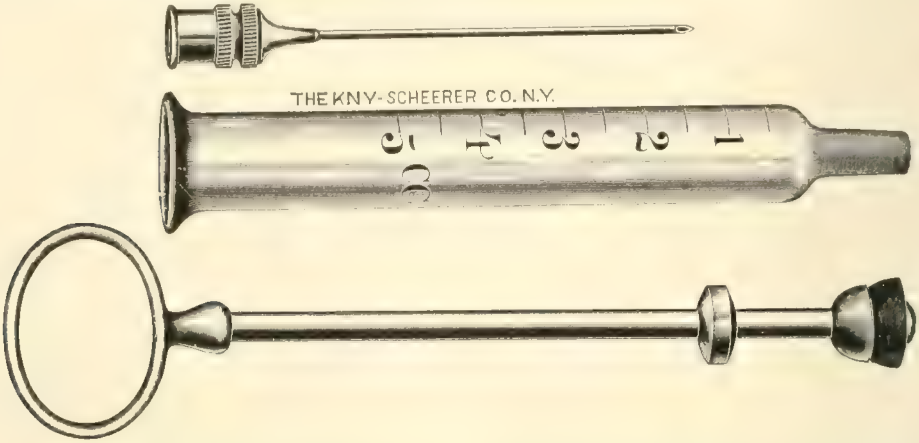


FIG. 108.—Pravaz Syringe with Fibre Packing. This type allows easy introduction of tablets or powder into the syringe to be dissolved in cerebro-spinal fluid. Note the short bevel of the needle point. (After Matas.)

Tropococain may be substituted for cocain. Its maximal dose is 30 to 40 mgm. The duration of the anæsthesia is less than with cocain.

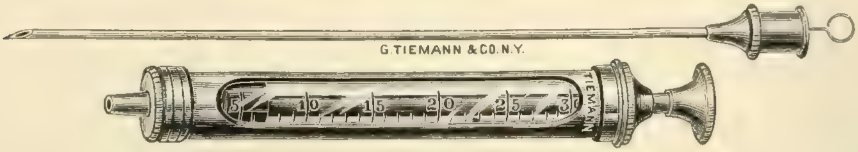


FIG. 109.—Tuffier Needle. Actual size, 9 cm. long, with short, sharp bevel. The syringe is the ordinary metal and glass syringe holding 2 cubic cm. This is the most convenient syringe for ordinary local methods. (After Matas.)

Eucain B is highly recommended on account of its slight toxicity. The dose is 15 to 20 mgm. for anæsthesia of the rectum, perineum, and legs; 25 to 35 mgm. for anæsthesia of higher regions.

Magnesium sulphate has been recently used, and has already been referred to.—*Stovain* has apparently given the best recent results with a minimum of bad effects. Bier and Donitz state that in 102 cases in which it was employed by them, 80 per cent were free from any dangerous or unpleasant symptoms. In the remaining 20 per cent there was slight collapse once, and vomiting seven times, and in none were serious after-effects observed. It is stated by Bier that no deaths can be directly attributed to the stovain. Medical literature of the past year or so contains numerous expressions of the safety and efficiency of stovain for spinal anæsthesia, and at present the general consensus of opinion seems to be that it is the best. Its dosage is 40 mgm. for low and 70 mgm. for high anæsthesia. It can be sterilized in solution. Donitz recommends tablets containing stovain 20 mgm., suprarenalin $\frac{1}{10}$ mgm., made up with gum arabic. These can be sterilized and kept ready for use.

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* These tablets are now prepared by Parke, Davis & Co.

Technique.—Proper needles and syringes are a necessity. (Figs. 109 and 110.) Steel needles are best and should be about 7 to 8 to 10 cm. long and of a diameter of 0.8 to 1 mm. The point should not be too long, but with a short bevel. The syringe should be of glass with a capacity of 5 to 10 c.c. and so constructed that it can be easily opened for the introduction of the anæsthetizing substance. (Fig. 110.)

Preparation of Patient.—Practically no special preparation is necessary. It is generally advised that there be given a glass of wine or milk or a cup of coffee shortly before the operation, as it seems that the procedure is accompanied by less discomfort if there is something in the stomach.

Injection of Anæsthetic.—The method of Bier and most operators is to have the patient lying on the side, the back strongly bowed and the knees drawn up, *i.e.*, in a position of marked kyphosis, with lateral curving away from the side on which the injection is to be made. (Fig. 111.) Some prefer having the patient in a sitting posture at the time of the injection. The spaces between the lumbar vertebræ are available for puncture, and these become wider in the above position. The cord reaches in adults to the lower border of the second lumbar vertebra; hence the point of puncture is usually between the third and fourth lumbar vertebræ or the next lower interspace. (Fig. 112.) Donitz advises puncture between the first and second for high anæsthesia, and objects to the lateral curving as likely to lead to the production of one-sided anæsthesia. A line connecting the iliac crests passes through the fourth lumbar vertebra, and from this the next interspace is readily located. (Fig. 113.) The skin is cleaned and anæsthetized by freezing or by infiltration. The needle is now inserted about $1\frac{1}{2}$ cm. ($\frac{3}{5}$ inch) from the middle line and pushed obliquely upward and forward so

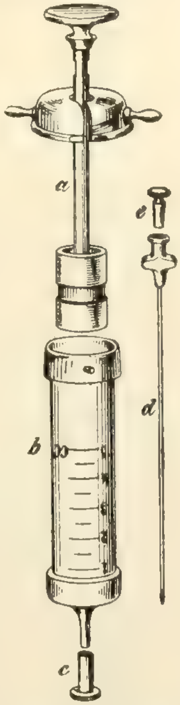

FIG. 110. — Glass Syringe with Metal Piston Recommended by Braun.

as to strike the dura in the midline. (Fig. 111.) If the needle point encounters bone, it is slightly withdrawn and its direction changed; sometimes it may be necessary to withdraw entirely and try another puncture. There is slight pain when the dura is penetrated, and immediately cerebro-spinal fluid flows from the needle. When the fluid flows freely, the syringe containing the anæsthetizing tablet or solution is attached to the needle and the anæsthetic dissolved in the cerebro-spinal fluid. Special care should be taken to secure a free flow of cerebro-spinal fluid before injecting the anæsthetic, as this is an indication that the needle has entered freely the subdural space. One should also be careful not to change the position of the needle while dissolving the anæsthetic or attaching the syringe. The anæsthetic is slowly injected, and in a little while the needle is withdrawn and the point of puncture sealed. The patient is now placed in the desired position for operation, and the preparation of the field of operation is completed while waiting for the appearance of the anæsthesia. Anæsthesia appears, as a rule, in about ten minutes, and its commencement and extent can be tested by pricking the skin with the point of a needle. Its duration varies from half an hour to several hours.

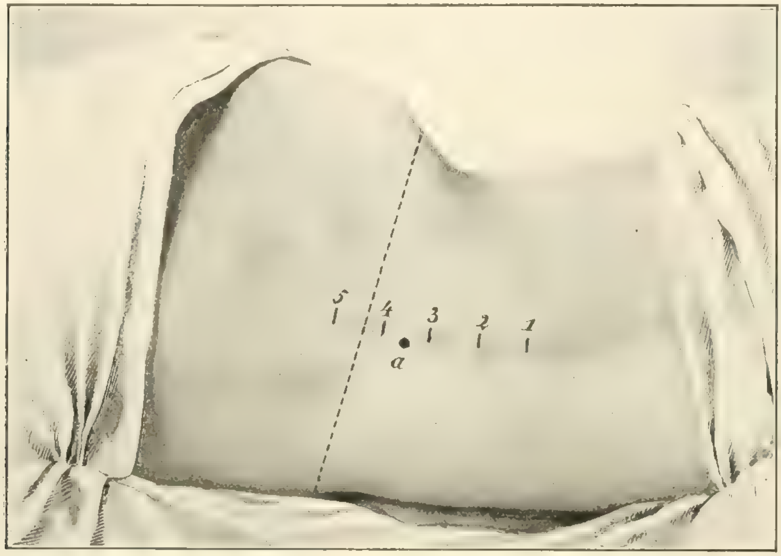

Fig. 111.—Patient Lying on Right Side in Position of Kyphosis and Scoliosis, showing Point of Puncture (*a*) in Relation to the Iliac Crests, which are Connected by the Dotted Line. (After Braun.)

Indications and Scope.—Undoubtedly spinal anæsthesia has a useful place in surgery. In Europe its popularity has increased much more rapidly than in this country. In looking over the reports of cases, one cannot fail to note, however, that in a great number of instances it might be replaced by the simpler local methods. For the performance of circumcision, the ligation of veins and the various operations for hydrocele, and for such simple procedures as the splitting of small fistulæ or the removal of small tumors, it certainly is better to employ local anæsthesia as obtained by the various methods. In inguinal hernia Cushing's regional procedure is too satisfactory to need to be replaced by spinal injection. Most of the amputations possible under spinal anaesthesia can be readily done by local means. In a certain class of cases it has a special application. In old and debilitated persons, diabetics and drinkers, where local means are not satisfactory and a general anæsthetic is perilous, lumbar anæsthesia is the method of choice. For hemorrhoids and rectal operations it has a

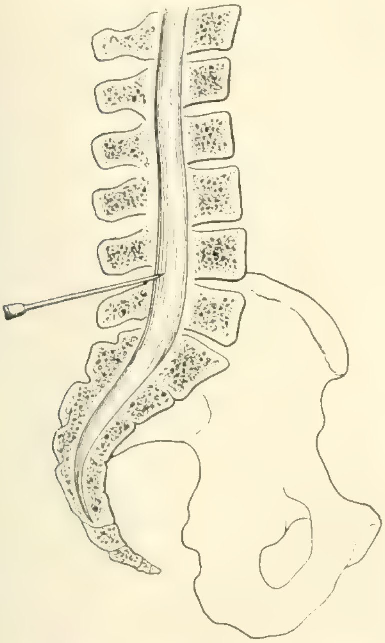

FIG. 112.—Direction of Needle Entering the Spinal Subarachnoid Space Below the Spine of the Fourth Lumbar Vertebra. (After Tuffier.)

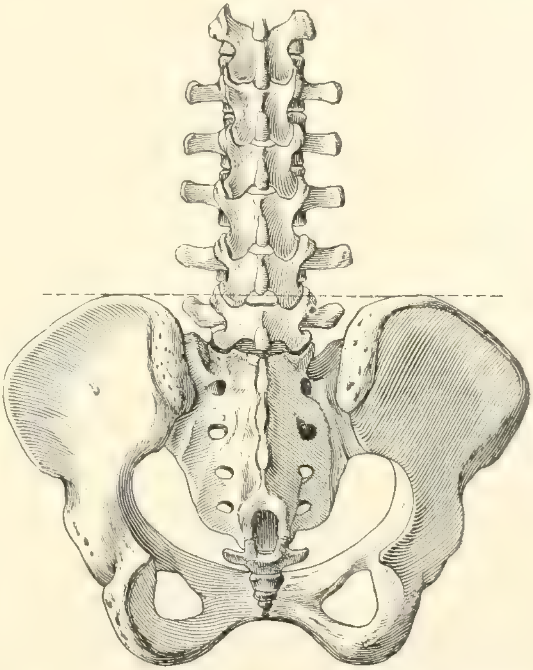

FIG. 113.—The Dotted Line Connecting the Iliac Crests Passes through the Fourth Lumbar Spine. (After Tuffier.)

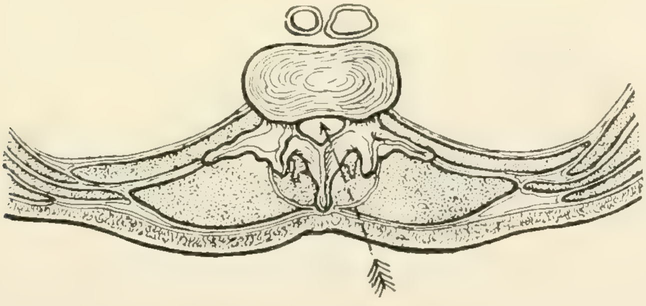

FIG. 114.—The Arrow Indicates the Direction of the Needle Introduced 1–1½ cm. from the Middle Line and so Slanted as to Reach the Dura in the Middle Line. (After Tuffier.)

special advantage, and in prostatectomy in the aged or debilitated it seems to have its best application, and may be the turning-point between success and failure. Also in certain instances where it may be desired to obtain the patient's consent to amputation after exploration, spinal anæsthesia offers a good solution of the difficulty. In military surgery it may have a useful field. The general impression of spinal anæsthesia—placing it in a dangerous light—has been obtained from the reports of cases in which cocain was used. With the introduction of adrenalin, this danger was decreased; and with the use of stovain and other compounds less toxic than cocain, spinal anæsthesia can no longer be held to be an especially dangerous procedure.

AMPUTATIONS AND DISARTICULATIONS.

By WILLIAM L. RODMAN, M.D., LL.D.,
and JOHN STEWART RODMAN, M.D., Philadelphia, Pa.

HISTORICAL NOTE.

Amputations, perhaps the oldest, certainly the most impressive of operations, were practised in the time of Hippocrates. "The Father of Medicine" did not write much of this class of operations, though it is known that he employed no particular method nor followed any special plan except that of cutting through dead tissue. Celsus, that great founder of the Alexandrian school, was in advance of his time in this as in other surgical procedures, and suggested that a circular incision be made between the dead and healthy areas, and it is believed that he practised this method. This Roman surgeon also knew of and used ligatures in tying bleeding vessels, but evidently did not apply them to vessels cut in amputating, depending upon hot irons and lint to check the hemorrhage. Galen, who followed Celsus, living A.D. 131–200, returned to the teachings of Hippocrates, and so unfortunately the method of Celsus was abandoned for the time. Archigenes, who lived in Rome before Galen, tied vessels before amputating and also is thought to have used some form of tourniquet, but he too failed to tie vessels severed by the amputating knife, still depending upon hot irons for hæmostasis. Practically no progress was made from this time, the second century, until Ambroise Paré, in the sixteenth century, applied ligatures to the severed vessels. This of course was an enormous stride in advance, and from this period amputations were more successful in accomplishing their purpose. The Spanish windlass, for which Morel of France and Young of England are both given credit, was invented and put into use during the seventeenth century; and at about the same time the circular method of amputating, originally taught by Celsus, was revived and became one of the accepted methods of operating from that period onward. Cheselden and Petit, the former of England and the latter of France, seemed to have suggested at the same time, and independently of each other, that the skin with the superficial fascia be divided at a different level from the underlying soft parts, but they still sawed through the bone at the same level at which the muscles were divided. To Bell and Key belongs the credit of the modern circular method, they having proposed it during the latter part of the eighteenth century. In 1679 Lowdham of Exeter, England, suggested, and Young of Plymouth described, the first flap operation. To Ravaton of France belongs the credit of introducing the double-flap operation. This he did in 1739, but, some years before this, the popular transfixion method of cutting musculo-cutaneous flaps had been used. Liston and Guthrie of England; Dupuytren, Roux, and Larrey of France; and Klein and Langenbeck of Germany, popularized the flap operation. Thus we have briefly followed the evolution of the circular and flap operations, which, with their various modifications, are still in practice to-day. The advent of asepsis has materially changed the indications for such a drastic procedure as amputation, just as the discovery of anæsthetics has materially lessened the element of speed which was so necessary in the past. At the present time flaps may be deliberately fashioned to suit the operator, and vessels may be secured and ligated as they are cut.

GENERAL CONSIDERATIONS.

Indications.—It is very difficult to dictate hard and fast rules for this class of operations, especially to the modern surgeon. It must be largely left to the judgment of the operator, and he, remembering that amputations are and should be the "*dernier ressort*," must do them as infrequently as possible, and then, with rare exceptions, only to save human life. Even in modern times many a person has needlessly lost what might have made a useful limb, through ignorance or unnecessary haste on the part of the surgeon. Generally speaking, the indications for amputation can be divided into: (A) those dependent upon traumatism, and (B) those independent of traumatism.

(A) Indications Dependent upon Trauma.—Fortunately, compound fractures and dislocations rarely call for amputation at the present day. For this we are indeed thankful when we remember that amputation was the rule until the advent of Listerian principles. The usual injuries requiring this procedure to-day are the severe railway accidents in which the limb has been mangled, the bone or bones comminuted, and the soft parts lacerated. It is frequently said that if more than two inches of bone is comminuted, especially when accompanied by laceration and tearing of the soft structures, amputation should be the rule. If the main artery is torn so as to make its repair impossible, then amputation should be performed. When all the soft parts within a certain area are completely devitalized, in fact reduced to a pulp, although the bone remains intact, amputation will be necessary, as sloughing of the injured parts is certain, despite rigid asepsis. Should this event be allowed to occur, the danger of general sepsis will be great, because of the favorable soil offered to infectious micro-organisms.

(B) Indications Independent of Trauma.—Under this heading we shall consider: (*a*) gangrene in its various forms; (*b*) malignant growths; (*c*) perforating ulceration, which spreads sepsis; (*d*) cellulitis; (*e*) chronic joint disease; and (*f*) malformations, either congenital or acquired.

(*a*) *Gangrene.*—It is not within the scope of this chapter to describe gangrene as a surgical disease, giving its causes, symptoms, and clinical course, but rather to refer to its manifestations as an indication for amputation. (See article on Gangrene in Vol. II.) To do this best it is perhaps well to state that gangrene may be divided into the following four varieties:

1. Symptomatic gangrene, or that in which traumatism plays but a minor part; this variety being again subdivided into: gangrene from embolus; senile gangrene; diabetic gangrene; Raynaud's disease, etc.

2. Traumatic gangrene, which may be subdivided into: direct, depending upon direct violence to the parts; and indirect, depending upon indirect violence, or where the lesion involves the vessels some distance above the spot where gangrene occurs.

3. Infective gangrene, depending upon the invasion of infectious microorganisms, this class being subdivided into: acute, actively spreading gangrene; hospital gangrene, practically obsolete at the present day; necrosis of bone; noma pudendi; cancrum oris; carbuncles and perhaps boils.

4. Thermic gangrene—frost-bites; burns. (Vide Vol. II.) (In the above we have followed largely the classification of Rose and Carless.)

In embolic gangrene it is well to maintain rigid asepsis until a line of demarcation between dead and healthy tissue has appeared, and then to amputate just above this line. If sepsis sets in, it may be necessary here, as in other forms, to amputate much earlier and higher than if asepsis had been maintained.

When the surgeon has to deal with senile and diabetic gangrene it is now an accepted principle that he should amputate early and well above the gangrenous process, as these varieties of the disease are prone to recur in amputation flaps. In gangrene of the foot, for instance, amputation at the knee, or preferably at the lower third of the thigh, should be practised so as to secure well-nourished flaps. Amputation below the knee generally means recurrence of the gangrene in the flaps, regardless of the care and method used in treating these parts, and especially is this true if the wound becomes infected.

If the case be one of indirect traumatic gangrene, it is well to wait for the formation of a line of demarcation, and to amputate above this line unless sepsis has already set in, when early and high amputation should be resorted to. In direct traumatic gangrene an effort should be made to save the limb; but if this is clearly impossible, because of the extent of the injury or the presence of infection, immediate amputation should be done.

Delay is most dangerous when dealing with acute, rapidly spreading gangrene of the infectious type, and high amputation only should be considered.

(*b*) *Malignant growths* may necessitate amputation when they involve the bone, soft parts, or both, of a limb, and this event is especially likely to take place when the tumor has an unusual tendency to rapid growth and to the early formation of metastases. Of the tumors belonging to this category epithelioma, carcinoma, and sarcoma may be mentioned.

(*c*) *Perforating ulcer* occasionally may require the sacrifice of a portion of a limb owing to its incurability or a tendency to spreading infection.

(*d*) *Cellulitis*, on account of the danger of its causing general septicaemia, should be mentioned as a possible indication for amputation; as a rule, however, it should respond to local measures.

(*e*) *Chronic joint disease*, rebellious to other less drastic measures, may call for amputation.

(*f*) *Malformation and deformities*, congenital or acquired, may be relieved by amputation, although this course should be left to the patient's desire.

METHODS OF CONTROLLING HEMORRHAGE.

The Tourniquet and Esmarch's Bandage.—As far back as the second century Archigenes, a Roman, was known to have used a variety of tourniquet, probably a simple band which he applied around the leg above the site of proposed amputation.

In the seventeenth century Morel introduced the Spanish windlass, and in 1702 Petit gave to the profession the screw tourniquet, which has been used either in its original or in a modified form ever since. (Fig. 115.) By means of this device the main artery of a limb may be compressed while the superficial circulation is, at the same time, occluded. At a somewhat later date there was instituted a mechanical device without a band, and by this means the main artery was compressed without interfering with the remainder of the circulation. In recent years hemorrhage has been controlled either by Esmarch's or Lister's method, or by digital compression.

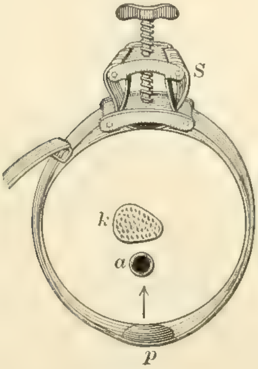

Fig. 115.—Petit's Tourniquet. *S*, Screw for adjusting degree of pressure; *k*, bone in centre of limb; *a*, artery; *p*, unyielding pad, by means of which pressure is exerted upon the artery.

Esmarch's rubber bandage, applied by direct spirals without reverses, and supplemented by his elastic tourniquet, has for many years enjoyed wide popularity as a prophylactic measure to prevent hemorrhage. (Fig. 116.) While there are distinct advantages possessed by this method, undoubtedly there are certain disadvantages. The advantages are that it effectually prevents hemorrhage during the operation, saving to the patient even the amount of blood that was in the limb prior to the application of the rubber bandage, and that it lends to a nervous operator a certain sense of security while operating. Its disadvantages are perhaps as weighty and are certainly more numerous. In the first place, there can be no doubt that Esmarch's bandage, when applied to septic limbs, may dislodge blood-clots, disseminate infection, and thus cause both embolism and septicæmia. In the second place, if the limb to be amputated is the seat of malignant disease, there is the danger that the pressure may force malignant particles into the blood stream, causing metastases to result. Other disadvantages, some of them minor, may be urged against the tourniquet used in this method. There is a great increase in the capillary oozing after the removal of the apparatus, due to vasomotor paralysis caused by pressure. This oozing requires that considerable time be spent in checking it and that many more ligatures be used than would otherwise have been necessary. It might also be possible that the tourniquet would set up a superficial sloughing, which of course would retard the progress of repair. Further, if the instrument is carelessly applied, pressure upon nerves as well as blood-vessels may cause a temporary paralysis of the stump. Moreover, tourniquets sometimes slip, thus greatly embarrassing the operator and endangering the life of the patient. Despite the objections mentioned, Esmarch's bandage and tourniquet are still popular in this country and have yielded good results. The apparatus should never be employed in septic or malignant cases.

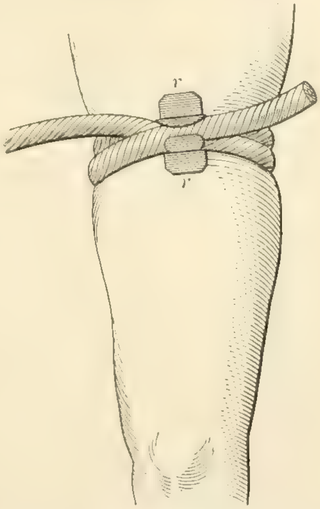

FIG. 116. — Esmarch's Elastic Tourniquet. (The bandaging of the lower part of the limb is not shown.)

Lister's Method.—Lister's method has proved to be very satisfactory and has to a degree supplanted Esmarch's rubber bandage. According to this method the limb should be elevated and stroked from extremity to base (hip or shoulder), the elevated position being maintained until the limb becomes anæmic. After this has been accomplished, a rubber tourniquet is applied to the base of the limb. Surely, this is following Esmarch's principle, but it will prove less dangerous and quite as efficient.

Digital Compression.—By some writers, notably Treves, digital compression is warmly advocated. Its advantages are that direct and well-localized compression is applied to the principal artery alone, the venous channels being left to drain the part of venous blood; that this compression need not be applied until it is actually required, being relaxed instantly when desired; and that the nerves escape compression, thus obviating all danger of paralysis. In carrying out this method, however, the operator should have the services of an assistant who possesses anatomical knowledge and is willing to devote his entire attention to this part of the procedure. In the case of an amputation which requires that this compression be kept up for a considerable period, two or more assistants should be at hand to relieve each other in this duty. Special methods of preventing hemorrhage, such as are used in individual amputations, like those of Wyeth and Senn, will be described when we come to consider those operations.

THE AMPUTATION STUMP.

To secure for the patient a serviceable stump is a duty of the operator, second only to that of saving life. To be serviceable the stump must, first, be painless; second, it must be able to stand pressure, especially in the case of the lower extremities—in other words, the cicatrix should lie to one side of the surface pressed upon; third, it must be well nourished, and the skin covering it should be freely movable; and, last, it should be of good shape.

(*a*) **Freedom from Pain.**—Painful stumps may be due to a variety of causes, but perhaps the most common is pressure upon the nerves which are left long. Dissection of these stumps often shows that a bulbous enlargement has taken place at the exposed ends of these nerves, the enlargement being due to an overgrowth of the neurilemma or nerve sheath. To these growths the name of false neuromata, or "amputation neuromas," has been given. Pain due to this cause should be obviated by cutting nerves high up. Overstretching of the skin, which can easily be prevented by making generous cutaneous flaps and thus allowing for retraction, is another cause of painful stumps. When the bone or bones are carelessly sawn, spicula are often left behind to irritate the surrounding tissue, thus becoming a fertile cause of pain and incapacity. Exostoses growing from the divided ends of the bones, and unequal retraction of muscles causing traction on the cicatrix, are other causes to be considered. Finally, if no tangible cause of pain be present, as is often the case, the blame may be laid on hysteria, neuralgia, or rheumatism.

(*b*) **Ability to Withstand Pressure and Pressure-Stretching.**—A stump incapable of bearing pressure or pressure-stretching, without pain to the patient or decided interference with its blood supply, would be worse than useless and a constant source of annoyance. To possess this pressure-bearing quality the stump must be firm, free from all the conditions mentioned above as causing painful stumps, with abundant blood supply and with the cicatrix so placed that it escapes all or the greater part of the pressure. Treves divides cicatrices into: "(1) Terminal, when the scar occupies the actual extremity of the stump. (2) Lateral, when it occupies one or more of the sides of the stump or parts of its circumference—as, for example, when the wound is placed upon the anterior, posterior, or internal surface of the limb. (3) Termino-lateral, when a terminal cicatrix is prolonged on to one or more sides of a stump."

A terminal cicatrix in a stump of the lower extremity would necessarily be called upon to withstand much more pressure than the same variety of cicatrix situated in a stump of the upper extremity. It will therefore be necessary for the operator—if the lower extremity be the part that needs to be amputated—to select a method of operating that will not yield a terminal cicatrix. This does not hold true of the upper extremity, however, as here no pressure to speak of is brought upon a terminal cicatrix. In fact, in the movements of an artificial arm a lateral cicatrix would be pinched and pressed far more than a terminal one under the same conditions. Therefore a cicatrix in the latter position is to be preferred.

(*c*) **A Serviceable Stump.**—We stated that for a stump to be serviceable, it should be well nourished and the skin covering it freely movable. In order to satisfy this prerequisite the operator should be careful to preserve the larger arteries that supply the stump, in so far as this is possible. Cutaneous flaps should be cut long, the operator remembering that normal skin retracts one-third of its length and also that œdematous skin is incapable of retraction. A periosteal covering of the sawn ends of bones, especially when connected with normal overlying tissue, is the best kind of flap.

(*d*) **A Well-shaped Stump.**—A good stump should be of proper shape. By this we mean that it should be rounded and well-cushioned. Therefore the operator, while remembering that a skin flap normally retracts one-third or more of its length, should also bear in mind that muscles retract unequally according to their variety and attachment. For instance, muscles that are free from their origin to their insertion and are narrow, like the sartorius, contract to a much greater extent than do broad, widely attached ones like the brachialis anticus. Bones should be sawn correspondingly high to prevent subsequent protrusion due to future growth, an increase quite usual in young subjects. Therefore, a good stump should be: 1st, without pain; 2d, capable of withstanding pressure; 3d, well nourished and covered with freely movable skin; and 4th, of good form.

There is a form of bad stump that occurs so frequently as to merit description—namely, the *conical stump*—a stump having the shape of a cone, due to the projection of the end of the bone, or to the retraction of the skin and muscles, or to both. The end of the bone is the apex of the cone, and often becomes necrosed. A stump may be conical from the beginning or may become so afterward. When it is conical at first, it may be assumed that the bone has been divided too low down or that the soft parts have been cut too short. These conditions can be avoided, and should be in every case; but, no matter how skilled the operator may be, it will not always be possible to prevent a stump from becoming conical. Conicity may result because of: (a) Unusual secondary contraction of the muscles; (b) Loss of tissue by sloughing or suppuration; (c) Subsequent growth of the bone.

This latter cause of conicity applies especially to young subjects, although, as a rule, the epiphysis of the stump, after functional stimulus has been removed, fails to develop like its fellow of the opposite side. There are, however, exceptions in which the epiphysis continues to develop, and in these cases there is eventually painful projection of the end of the bone. This is likely to take place in amputation through the humerus and the femur.

METHODS OF AMPUTATING

There are various methods, as, for example:

1. Circular.
2. Modified Circular.
3. Elliptical.
4. Racquet or Oval.
5. The Method in which Several Flaps are Employed.

1. **Circular Method.** (Figs. 125 and 126.)—The circular method is the oldest as well as the simplest, and is, perhaps, the one most frequently employed. A circular incision dividing skin and superficial fascia is made, according to the degree of retraction, at a point not less than one-fourth of the circumference of the limb below where the bone is to be sawn. The operator should stand to the right-hand side of the limb to be amputated, the assistant to the left. The latter should put the skin on the stretch, in which manipulation the operator may help with his left hand. The surgeon, holding the amputating knife firmly with the right hand, commences his incision from within outward, using, on the dorsal aspect of the limb, the heel of the blade first and carrying the incision round the limb firmly and evenly, with only sufficient pressure to divide the skin and superficial fascia. These tissues should now be allowed to retract, it not being necessary in all instances to separate them from the underlying parts. In a like manner the superficial muscles should be divided, and they in turn allowed to retract. At a still higher level the deep muscles are divided and retracted. Now the periosteum may be separated from the bone, dissected up to the highest level of muscle division, and there the bone should be sawn through. Cutting the nerves, ligating the vessels, etc., complete the procedure of severing the limb.

It should be remembered that the cicatrix will be terminal. This method is especially applicable where there is one bone well surrounded on all sides by muscles, as in the thigh or arm. Where the subcutaneous tissue is scanty and therefore the skin is close to the bone, as at the wrist, it will be found advisable to make a skin cuff which can be turned back and the underlying tissue severed with one circular sweep. This is not as desirable as the circular method just described, as more damage is done to the tissues and undoubtedly there is the possibility of interfering with the blood supply. These two varieties of the circular method may be combined to obviate the results of contraction of the skin in certain parts of a limb. The cuff method is limited by many to amputations through the lower third of the forearm and leg and at the wrist.

2. **The Modified Circular Method.**—The usual manner of modifying the circular method is to join to the circular incision a vertical one, either on the anterior dorsal or lateral aspect of the limb. The only advantage in so doing is to loosen the skin so that it may be dissected up in flaps. It will be well here to mention Syme's amputation, or rather Liston's. Liston made two semilunar incisions and dissected up the skin to the point where these two incisions joined. Syme slightly modified this method by prolonging the dissection of the skin past the point where the two incisions met. He used this method extensively and it consequently became known as Syme's amputation instead of Liston's.

3. **The Elliptical Method.**—Although considered a distinct method, the elliptical is really a modification of the circular method. An elliptical skin incision (to allow for unequal retraction) is made, and a cuff turned up. The muscles are divided as in the circular method. It is claimed by the English that Sharpe, of Guy's Hospital, was the originator of this method, but the French attribute it to Souppart. It is well illustrated by the elliptical disarticulation at the elbow and by Guyon's supramalleolar amputation.

4. **The Oval or Racquet Method.** (Fig. 120.)—This method is particularly applicable to disarticulations at small joints, such as the metatarso-phalangeal. Credit for it is due to Scoutetten, who introduced the oval method in 1827. The incision is oval with one end somewhat pointed, so that the wound is closed in its vertical axis.

Malgaigne, in 1837, in order better to expose the joint, prolonged or rather added to the apex of the oval a dorsal incision. Hence the term "racquet" incision, the oval being the racquet itself, while the dorsal incision is the handle. While this incision is especially well adapted to amputations through the smaller joints, there are certain disarticulations, namely, at the shoulder and hip, where it is also employed.

5. **The Various Flap Methods.**—Flaps may be divided into:

(A) Cutaneous, including superficial fascia and skin.

(B) Musculo-cutaneous.

(C) Periosteal.

As to which is the superior—the musculo-cutaneous or the cutaneous—it is difficult to judge, since they have yielded equally good results and since each has its own indications.

Flaps may be fashioned either by:

(*a*) Transfixion and cutting outward.

(*b*) By cutting from without inward.

(*c*) By dissection.

TRANSFIXION. (Fig. 129.)—It is in this method of cutting flaps that the older surgeons excelled. The surgeon stands at the right-hand side of the limb to be amputated, introduces the point of his knife in the lateral aspect of the limb opposite the point where the bone is to be sawn, and pushes the blade through the tissues anterior to the bone, raising the handle slightly to allow the tip of the blade to emerge at a point directly opposite that of entrance. With a gentle sawing motion in an oblique direction the blade is carried through the soft parts until the first flap is cut. This being retracted, the point of the blade is again introduced at the same place as before and pushed behind the bone, the handle being depressed so as to make the incision connect with the internal incision. In like manner the posterior flap is cut a little longer than the anterior. This too is retracted by an assistant, the remaining soft parts are divided, and the bone is sawn. After the blood-vessels have been tied, and nerves, tendons, etc., suitably cut, the procedure is finished.

MAKING FLAPS BY CUTTING FROM WITHOUT INWARD AND BY DISSECTION.—In these methods the skin incision is outlined with a small knife and then the soft parts are divided. The manner in which the scalpel is held, while this manipulation is being carried out, is important. Its edge should be directed toward, instead of away from, the bones, so as to avoid unnecessary interference with the blood supply of the integuments. When the flaps are to be cut from within outward and dissected up, as in the method "*par désossement,*" the skin is allowed to retract. Flaps may be single or double. If the flap is to be single, after the original idea of Lowdham, the entire flap tissue is taken from one surface of the limb. This kind of flap is used where the tissue of one aspect is either destroyed or diseased, while that of the opposing aspect is healthy. More commonly used than the single flap are the double flaps, originally suggested by Ravaton, but since modified indefinitely and needlessly by many operators. The most important of these modifications will be treated in detail when the operations with which they are concerned are described. In general, it may be said that flaps which are rounded at the ends, or V-shaped, fit better and result in more satisfactory stumps than those which are square.

THE CHOICE OF A METHOD.—In choosing the best method for any given case the surgeon must use his judgment, based upon a sound knowledge of the principles underlying amputation. He should remember that the day for dramatic surgery has passed, and with it the "brilliant" amputation. It is of primary importance to save all tissue practicable, to provide as small a wound area as is consistent with propriety, to provide healthy and well-nourished flaps, to expose the bone only at the proposed saw-line and and to cover it efficiently with the soft parts. The main vessels should be cut transversely. Simplicity of method is desirable inasmuch as it insures the speedy completion of the operation, which is oftentimes a necessity. The cicatrix, as stated before, should be well adjusted and made as free from pressure as possible, and good drainage should be provided for the wound. Other things being equal, the circular method will yield a smaller wound area than any of its modifications or any of the various flap methods. It is also simple in technique and hence readily performed, but there is more chance of a conical stump from this circular method, if used injudiciously, than from any other, because the skin and muscles, for reasons already mentioned, may retract too greatly and unequally. The elliptical and oval methods are well adapted to the special amputations in which they are used. The flap methods and their indications have already been given. (Page 271.)

INSTRUMENTS AND OTHER AGENTS NEEDED FOR AMPUTATION.

It will be necessary to have at hand:

1. Agents for controlling hemorrhage.
2. Instruments for the cutting and subsequent trimming of the soft parts.
3. Agents for the proper coaptation of the flaps.
4. Agents for the support of the stump.

1. **Agents for Controlling Hemorrhage.**—The prophylactic control of hemorrhage has already been discussed. For the control of the bleeding during the operation hæmostatic artery forceps and ligatures, either of catgut, of Pagenstecher's celluloid thread, or of fine silk, will be required. After the soft parts are divided, the bone sawn through, and the main vessels ligated, an assistant should carefully loosen the tourniquet. As this is done the smaller vessels will bleed and it will be an easy matter for the surgeon or his assistant to clamp these vessels and ligate them. Torsion may be applied to vessels which are not sufficiently large to warrant ligation. If oozing continues, the application of very hot water will be found sufficient to check it. If there be oozing from the divided end of the bone, hot wet gauze pressed upon it should check the oozing. Ice may be used for this purpose instead of the gauze. Some authors state that, should pressure fail to check this oozing, "the sharpened edge of a wooden match" may be used as a plug. "This plug," writes Treves, "which so many authors allude to, is probably intended to be no more than a picturesque example of fertility of resource." A much better plan and more in keeping with aseptic surgery is to plug the opening with Horsley's antiseptic wax, so often made use of in trephining, or perhaps with catgut.

2. **Instruments for the Actual Cutting and Subsequent Trimming of the Soft Parts.**—The following instruments should be at hand for the proper performance of an amputation: amputating knives and scalpels, saws, periosteal elevator, retractors, rongeur forceps, lion-jaw forceps, scissors, dissecting forceps, and tenacula.

Amputating Knives and Scalpels.—The old amputating knife, one with a very long, pointed blade and a short handle, is now thought by many to be a very objectionable instrument, and has been practically discarded. In its place one with a much shorter and less tapering blade and a stout handle is used (Fig. 117). The catlin knife, double-edged, was formerly thought to be necessary when dividing interosseous soft parts, but its use has largely been dispensed with. The amputating knife, according to Bryant, should be equal in length to one and one-half times the diameter of the limb to be amputated. Scalpels will be necessary for dissecting up flaps and for dividing nerves, tendons, and soft parts; and in fact, with two or three large-sized scalpels, the entire division of the soft parts may be accomplished. Therefore no operator should feel that it will be impossible for him to amputate without an amputating knife, for a scalpel is often adequate for the purpose.

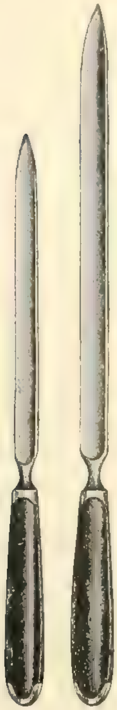

Fig. 117.—Long Amputating Knives of Two Sizes.

Saws.—Several different varieties may be used; namely, the ordinary broad-bladed saw, a bow-backed saw, Butcher's bone saw, a Gigli saw, and a lifting-back saw. The first two are the ones generally used and in most cases they will be sufficient. They should have fine short teeth. Butcher's saw will be of service in excisions, the Gigli and lifting-back saws in severing small bones and spicula of bone.

Rongeur forceps and Liston's bone-cutting forceps may be employed in smoothing the ends of the bones, but should not be used in severing them, as necrosis is often caused thereby.

Lion-jaw forceps may be required to steady the bone while sawing it or to remove large fragments.

The use of the other instruments mentioned calls for no special comment.

3. Agents for the Coaptation of Flaps and for Drainage.—Needles, variously curved, threaded with catgut—if any subcutaneous stitching is to be done—should be at hand. For cutaneous suturing, straight needles, threaded with silkworm gut or horsehair, may be employed. A good way is, first to use a certain number of silkworm-gut relaxation sutures, and then to bring neatly together the edges of the skin with a "buttonhole stitch" of horsehair.

Drainage.—"When in doubt, drain," has become a surgical tenet. With better and more frequent drainage, results have improved. It is safe to make use of drainage, as a routine procedure, in all of the larger amputations, as those of the arm, forearm, thigh, and leg, because the wound area is large and there will be a certain amount of oozing. When amputating for local disease it is well to drain, since sinuses may be opened, and a risk is taken if the wound be too tightly closed. Various forms of drainage are used—as, for example, rubber tubing, cigarette drainage, and gauze drainage. If there be no discharge but serum, then cigarette or gauze drainage at a suitable part of the wound should prove sufficient. However, if actual suppuration is in progress or is feared, rubber tubing should be employed. Where a large dead space remains, into which hemorrhage must occur, tube drainage for from twenty-four to forty-eight hours is usually the best.

Dressing the Stump.—A bountiful supply of sterile gauze, either wet or dry, usually the latter, should be applied. Over this may be placed absorbent cotton, and both gauze and cotton covered by a layer of non-absorbent material. The stump should be supported on a well-padded splint, to which it should be secured by a carefully applied bandage. While the patient is in bed the stump should be kept in as comfortable a position as possible and at a somewhat higher level than the rest of the body, pillows being used for the purpose. This position is not only more comfortable for the patient, but also facilitates the return of the venous blood from the extremity of the stump. Muscle contraction is also much lessened by the splint, thus contributing to freedom from pain. Without a well-padded splint, spasm of the muscles is sometimes severe, necessitating the use of morphine.

Manner of Using the Amputating Knife.—As has been said before, this instrument may be dangerous, so that care in its use is necessary. If the circular method is to be adopted, the operator, if standing to the left of the patient, should grasp the handle of the knife between the thumb and forefinger of the right hand. (Fig. 128.) He should place the left hand just below the site of the incision, and now stooping slightly he should begin his incision on the upper and inner surface of the limb, carrying the blade toward himself with a gentle sawing motion. The incision can be carried in this manner entirely around the limb, the operator rising to an erect position as it advances over the upper surface, to meet the point of commencement. The procedure may be reversed, a start being made from the upper and outer surface and the incision continuing around the limb; but this is not so desirable, as thus the blood to a certain extent will obscure the line of amputation. If a skin cuff is to be dissected up, the middle portion of the blade should be used, and not the point, on account of the danger of buttonholing. Several scalpels should be at hand for use in dissecting up flaps, etc. Tendons and nerves should be put on the stretch and divided high up. It is well to sew open tendon sheaths, thus closing them and preventing the possibility of infection spreading through these channels. Formerly a double-edged knife was used for dividing the interosseous soft parts, as in amputations of the forearm or leg, but at the present day it is not considered necessary, as a single-bladed knife may accomplish the same purpose. It should be remembered, however, when these interosseous structures are being divided with a single-bladed knife, that, if it be desired to change the direction of the cutting edge, the blade should be withdrawn and reintroduced rather than turned, for in turning it there is an unnecessary bruising of the tissues. Before making the incision the operator should at least mentally rehearse the method he is about to practise, even marking the flaps with crayon if necessary, for, although it is no disgrace to trim flaps after they are cut, it is more satisfactory to have the first incision final.

The Use of the Saw.—Here, too, the operator should be careful, since from improper sawing of the bone necrosis has occurred. The bone should not be exposed above the saw-line. The saw should have fine teeth, which should be sharp. Beginning at the heel of the saw, long, even strokes should be used in dividing the bone. An assistant should hold the limb at right angles to the saw and should keep it as steady as possible. When the bone is almost sawn through, care should be taken lest the saw be clamped. If the direction of the stroke is somewhat changed and if its length and vigor are lessened, the danger of this happening will be reduced to a minimum. When two bones are to be sawn through, the larger and more fixed one should be attacked first, and then the smaller and more movable one should be included in the sweep of the saw, care being exercised to sever them simultaneously or the smaller bone first. If this is not done, splintering may occur.

Site of Amputation.—"Where shall I amputate this limb?" will always be a serious question for the surgeon to answer satisfactorily to himself. No hard and fast rules can be given to aid one in reaching the decision. Different conditions will demand different procedures. While it should be one of the chief objects of the operator to save as much tissue as practicable, his first duty is to save the patient's life and at the same time achieve the best practical results. In railway crushes, machinery accidents, etc., the tissues are generally bruised higher than is apparent, and this fact should be borne in mind in amputating for these conditions. Unless one amputates, in injuries of this nature, at a higher level than seems to be necessary, sloughing of the flaps will finally occur, making reamputation necessary. Amputation for gangrene has already been referred to in the section relating to indications for amputations. (Page 265.)

AMPUTATION IN SHOCK.

Amputations are commonly divided into immediate, primary, and secondary. An immediate amputation is one performed within six hours of the accident; a primary, when the operation is done within the first forty-eight hours; and a secondary, when it is done after the lapse of forty-eight hours.

Immediate amputation will necessarily often be done in shock. Only general rules can be laid down for the guidance of the surgeon's action; and he who expects to treat every case according to hard and fast rules of action, must be frequently disappointed. Shock, perhaps more than any condition encountered by the surgeon, will vary with the age, temperament, and general health of the patient, the nature of the violence inflicted, the presence or absence of pain, hemorrhage, etc. The rule generally followed by modern surgeons is to wait for reaction before amputating, for it is argued that the shock of the operation is an additional burden put upon the patient at a time when he is least able to bear it. While surgical sentiment is so nearly unanimous on this point, it is equally decided in regard to another, viz., that in a condition of profound shock, where it is believed that a mangled limb is keeping up and deepening this condition because of pain or loss of blood which cannot be well controlled, amputation should at once be done regardless of shock, whether it be mild or severe, provided, of course, that the patient's condition justifies the belief that he will survive the operation. Nothing is better established than the fact that shock may not only be perpetuated, but increased, by the presence of a mangled limb—one in which there is not only fracture of the bone, but extensive laceration of the soft parts. The special gravity of shock from railway accidents is often as much due to the mental terror which they cause as to the physical injury inflicted. The mental and physical shock combined render these injuries the severest of all. In railway surgery, he who ignores reaction and amputates in shock will often give his patient the best chance for life.

Ether is to be preferred to chloroform for operation in shock. It is a cardiac stimulant, while chloroform is a depressant. If the pulse improves in quality—coming up in volume and strength and diminishing in frequency in commencing anæsthesia—it is a most favorable omen, and should justify the surgeon in his determination to operate. If, on the contrary, the pulse does not improve or perhaps becomes weaker, one can believe that the shock may be dependent more upon some visceral injury than upon the condition of the limb. The propriety of amputating in the case of a patient suffering from severe internal injuries is questionable. The state of the body temperature should be given, in practice, the attention to which its importance entitles it. Wagstaff, who more than any one else has made a study of temperature in shock, has deduced the rule that no capital operation should be performed when the axillary temperature is less than 96° F. However, patients with a temperature below 96° F. have occasionally recovered after operation, though such instances are rare. One of the chief arguments favorable to amputation in shock is the large mortality attending intermediary amputation. While many deny that there is such a condition as delayed shock, it does sometimes occur; usually, however, delayed shock is due to concealed hemorrhage. In military surgery it is better to operate as quickly as possible, owing to the fact that the patient is more or less sustained by excitement. Wiseman, Sergeant Surgeon to Charles II., said, "If you operate, do so while the soldier is in heat and mettle"; and Ambroise Paré said, "Operate in sight of the battle-field." The additional depression inflicted by operating on one already in shock has probably been greatly exaggerated. The nervous system, under these conditions, is in such a state as not to be readily impressionable to further shock, and we believe that an amputation may add but little, if any, to it. Certainly this is so if the sensory influences are blocked, as Crile suggests, by cocain injected into the nerve, or, as Wainwright has demonstrated, by spinal anaesthesia. Stephen Smith has collected statistics of four hundred and thirty-nine recovered amputations. Thirty-six per cent were done within six hours of the injury, which means they were done during or near to shock; and in these he estimated that recovery was six per cent better than in those done in periods of reaction.

THE AFTER-TREATMENT.

The after-treatment depends upon the severity of the operation, the amount of blood lost, and the degree of shock which may be present. The patient's bed should be raised at the foot if there has been great loss of blood, and the patient himself surrounded with hot-water bags. Hot normal salt solution (temperature about 110° F.) should be given, as a routine measure, either by rectum or by hypodermoclysis. Should the pulse be extremely weak it will be necessary to employ venoclysis instead of hypodermoclysis or enteroclysis. If there be shock, which is usually present if an arm or leg has been removed, morphia, digitalis, and atropine should be discreetly given. It is also of advantage to bandage the remaining limbs, as this maintains their warmth and keeps the blood within the trunk itself. Unless they are obviously soiled, the primary dressings may be allowed to remain undisturbed for six or seven days, provided drainage has not been employed.

After the patient rallies from shock, his recovery should be uninterrupted.

SPECIAL AMPUTATIONS.

Amputation of the Fingers and Thumb. (Figs. 118–122.)—General Remarks.—As no mechanical device has as yet been, and probably never will be invented to take the place and fulfil the functions of the human finger, every possible portion should be saved. For example, the proximal phalanges of the middle and fourth fingers may be saved and be useful, owing to the power of the lumbrical muscles and the *vincula accessoria tendinum*. We have frequently seen this demonstrated. These phalanges will, however, most likely be serviceable if the tendons and metacarpo-phalangeal joints are not invaded. The phalanges of these fingers should be left if it be found necessary to remove the index and little fingers. Since the skin on the palmar surface is better adapted to pressure and more sensitive to tactile impressions than that of the dorsal aspect, the most satisfactory finger stump is one the end of which is cushioned by palmar skin, the cicatrix being located upon the dorsal surface. This result is accomplished by long palmar flaps.

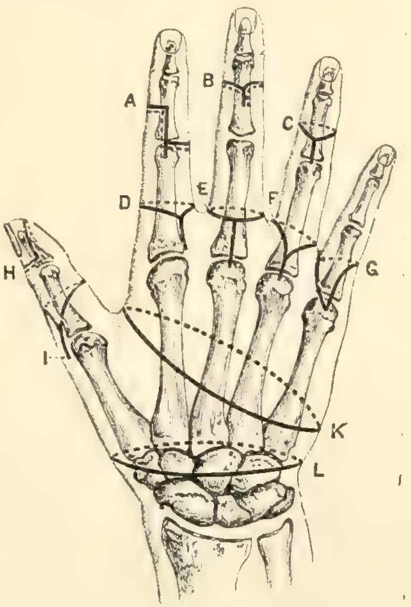

Fig. 118. — Amputation of Fingers. (From Treves' "Operative Surgery.") *A*, Disarticulation by single external flap; *B*, amputation by lateral flaps; *C*, disarticulation by oval or racquet incision; *D*, modified racquet incision for index finger; *E*, circular method, with vertical dorsal cut; *F*, incision *en croupière*; *G*, interno-palmar-flap method for little finger; *H*, disarticulation by single palmar flap; *I*, disarticulation by racquet incision; *K*, amputation of fingers with their metacarpal bones; *L*, circular disarticulation at the wrist.

Anatomy. (Figs. 118–120.) —As mentioned above, the skin of the palmar surface of the finger is thick, well accustomed to pressure, and possessed of tactile sensation. It is rather firmly associated with the underlying structures. The skin on the dorsal surface of the fingers and thumb is very thin, unaccustomed to pressure, and has less sense of touch. Beneath it there is a distinct layer of subcutaneous tissue. The knuckles are formed by the distal ends of the proximal bones. For example, the middle knuckle of the index finger is formed by the distal end of the first (anatomical) phalanx. The free edge of the web of the fingers, on the palmar surface, is about three-fourths of an inch beyond the metacarpo-phalangeal joints; that of the articulations between the second and first (anatomical) phalanges is one-sixth of an inch below the second knuckle; the line of articulations between the distal and the second phalanges is one-twelfth of an inch below the distal knuckle; and that of the articulations between the first (anatomical) phalanges and the metacarpal bones is one-third of an inch below the first knuckle. The phalanges of the fingers and thumbs are held together principally by an interior and two lateral ligaments and one capsular ligament. The lateral ligaments are inserted nearer the palmar than the dorsal surface. The glenoid (anterior) ligaments are attached to the bases of the distal bones. The digital arteries run along the lateral aspect of the finger nearer to the palmar than the dorsal surface. The dorsal digital arteries, except in the thumb, are so small that they can hardly be traced beyond the first phalanx. According to Deaver:* "The insertions of the flexor tendons are as follows: Each tendon of the flexor sublimis digitorum rests upon the corresponding tendon of the flexor pro-

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* "Surgical Anatomy," vol. i., p. 168.

fundus digitorum; opposite the metacarpo-phalangeal joints, the tendons of the flexor sublimis broaden, and opposite the middle of the proximal phalanges they split into two segments, between which pass the tendons of the flexor profundus; they reunite and again divide, to be inserted into the middle of both sides of the second phalanges; the tendon of the flexor profundus after perforating the tendons of the flexor sublimis passes on for insertion into the front of the base of the last phalanx. The tendon of the flexor longus pollicis passes between the two heads of the flexor brevis pollicis for insertion into the front of the base of the last phalanx of the thumb." The fibrous sheaths of these tendons are lined by synovial membrane and they thus form canals when they are opened. There are synovial reflections connecting the sheaths on the under surface to the bone. These reflections are broader near the insertions of the tendons and are called "ligamenta brevia," while the longer reflections, further away from the insertions, are called "ligamenta longa." Collectively these reflections are known as "vincula accessoria." The sheaths of the tendons of the index, middle, and fourth fingers do not pass beyond the annular ligament, but are bound down at the heads of the metacarpal bones; those of the tendons of the little finger and thumb pass beyond the annular ligament and communicate with the carpal bursa. The sheath for the little finger extends an inch and a half, while that for the thumb extends an inch and a quarter, above this ligament. By reason of this anatomical fact, therefore, it can readily be understood how infection may travel into the forearm from a focus of suppuration in the thumb or little finger. For the same reason, also, it is necessary to close these fibrous sheaths when they are divided in amputating through the fingers, since to leave them patent is to invite the development of a possible infection.

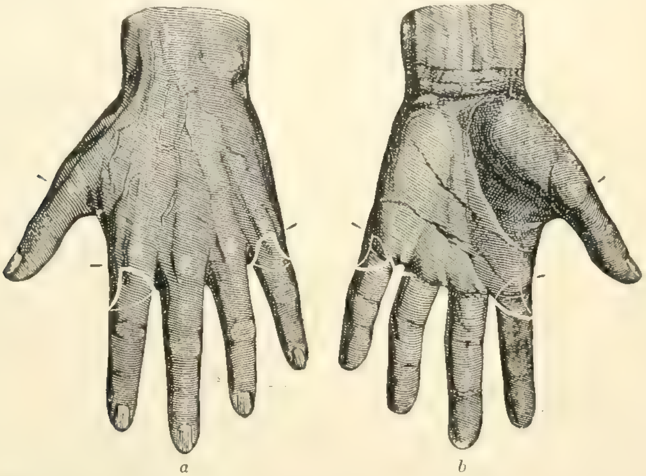

FIG. 119.—Methods of Disarticulating the Index and Little Fingers at the "places of election"; combined palmar and external flap for the index finger, combined palmar and internal flap for the little finger.—*a*, Dorsal; *b*, palmar aspects of the hand. (After Farabeuf.)

AMPUTATIONS OF THE PHALANGES OF THE FINGERS.—Amputation of the digital phalanges may be accomplished in several ways as:

1. By a single palmar flap;
2. By a long palmar and a short dorsal flap;
3. By two lateral flaps—(*a*) equal; (*b*) unequal;
4. By a single lateral flap;
5. By two equal antero-posterior flaps.

AMPUTATION OF A DISTAL PHALANX (first surgical or third anatomical).—Disarticulation of this joint is best done by a single palmar flap (*H*, Fig. 118), which should be equal in length to one and one-half times the diameter of the finger at the site of the amputation. A knife with a narrow blade should be employed. The surgeon, sitting with the patient's hand before him in a position of pronation, first makes a skin incision marking out the future flap. The point of the blade starts opposite the joint on the lateral aspect, midway between the dorsal and palmar surfaces, and ends at a point directly opposite to that of starting. The reason for the incision being midway between the dorsal and palmar surfaces is that one may avoid cutting the digital arteries which should be found in the palmar flap. After the skin incision has been completed, the tissues are divided from without inward down to the bone, along the line of incision, and the flaps are dissected free from the bone. The finger is now flexed and a dorsal incision is made over the base of the distal phalanx. The joint is opened and the lateral ligaments are divided. It now remains

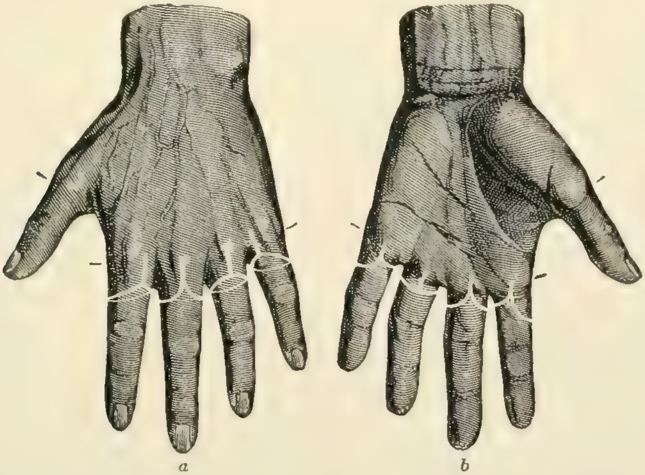

FIG. 120.—Adaptation of the Racquet Form of Incision to the Operation of Disarticulating Individual Fingers. In the case of the index finger the dorsal incision is made well over toward the middle finger, while the circular part of the incision descends to a lower level on the outer side of the finger; in the case of the little finger an analogous course is pursued, but here the dorsal incision should approach nearer to the ring finger and the circular part of the racquet should descend lower on the inner side of the digit. In operating upon the middle or the ring finger, the surgeon may make either a T-shaped or a Y-shaped incision, as he prefers. In all the operations two lateral flaps are obtained.—*a*, Dorsal; *b*, palmar aspects of the hand. (After Farabeuf.)

to divide the tendon of the flexor profundus digitorum and the glenoid (anterior) ligament. These structures are best severed with the finger extended and by cutting from below upward. The phalanx is now removed. There will be no vessel to tie or sheath to close. The distal phalanx may be amputated by a long palmar and a short dorsal flap. This is done in the same manner as for a single palmar flap, except that the latter is made about one and one-quarter times as long as the circumference at the site of amputation, while the dorsal flap is made one-third the length of the palmar. Jacobson and Steward advise that the flap be made by transfixion, but Sir Frederick Treves says that "in no operation upon the finger is it well to cut the flaps by transfixion. In cutting a palmar flap by this means there is danger of slitting up the digital arteries. The flap, moreover, is apt to be pointed and scanty and to contain fragments of tendon." Especially at the base is the flap scant.

Amputation of the Second Phalanx.—Amputation through the second phalanx beyond its middle is preferable to disarticulation at the first surgical phalangeal joint, because by this method the attachment of the flexor sublimis is saved. This amputation may readily be done by utilizing equal lateral flaps. (*B*, Fig. 118.) Dorsal and palmar incisions should be in the median line. It will be necessary to divide the tendon of the flexor profundus, the extensor tendons, and the expansions from the flexor sublimis tendon. The bone should be divided by a fine saw. It will be necessary to divide the digital arteries; they should therefore be ligated. The tendon sheaths should be closed.

Disarticulation at the First (Surgical) Phalangeal Joint.—This operation may be accomplished:

1. By unequal dorsal and palmar flaps;
2. By a single external flap.

Unequal Dorsal and Palmar Flaps.—The palmar flap is fashioned in the manner described for removing the distal phalanx and covering the exposed parts with a single palmar flap, except that this flap should not be cut quite so long. A length about one and one-quarter times the circumference at the site of amputation (instead of one and one-half times) will suffice. The dorsal flap should be equal to one-third the length of the palmar. Dissect up both flaps, expose the joint from above, and divide the lateral ligament as before. The digital arteries, according to their size, may or may not require a ligature. The tendons of the flexor profundus and the flexor sublimis may be sewn either to the extensor tendons over the end of the first phalanx or to the theca or the periosteum. Securing the tendon in this manner contributes to the usefulness of the stump. The tendon sheaths should be closed with sutures.

A Single External Lateral Flap (second joint). (*A*, Fig. 118.)—An external flap extending to the middle of the second phalanx should be mapped out and dissected up; it should contain all the soft parts down to the tendons. The joint should be fully flexed, the extensor tendons divided, and the lateral ligaments cut. Extend the fingers and divide from below upward the flexor tendons and the glenoid ligaments. Fix the tendons as described above and close the tendon sheaths. Ligate the digital arteries if necessary.

Remarks.—The last method is of advantage when the skin on one side is either destroyed or is the seat of disease. As a rule, it is not wise to amputate a finger at the first interphalangeal joint, as it leaves a stiff and ordinarily useless stump. The exceptions, according to Jacobson and Steward, are:

1st. In the case of the index finger the proximal phalanx will be a useful opponent to the thumb, as in holding a pen.

2d. In the case of the little finger, leaving the proximal phalanx will give greater symmetry to the hand when it is flexed, and it should accordingly be left if the patient desires it.

3d. In cases of amputation of all the fingers, the proximal phalanx of one should, if possible, always be left to oppose the thumb.

4th. When a patient insists on having the proximal phalanx left after the risk of stiffness has been explained to him.

Disarticulation at the Metacarpo-Phalangeal Joint.—These amputations are done more frequently than any of the operations before described. The second and third fingers are amputated either by

1. The oval method, or by
2. Equal lateral flaps.

1. *The Oval Method.*—This so-called oval method is not, as some think, the true "en raquette," nor is it the original oval method. Therefore it should more properly be called a modified oval method. The incision is begun on the dorsum of the hand, about three-quarters of an inch above the head of the metacarpal bone. The knife is thrust down to the bone and the incision carried forward over the head of the metacarpal bone, on to the base of the proximal phalanx. Here the incision branches, and the blade is carried obliquely over the root of the finger, first over one side and then over the other. These two lateral cuts are joined by a transverse one on the palm of the hand. (*F*, Fig. 118.) The tissues may now be divided down to the bone, the extensor tendons being cut. In order to facilitate the work of the operator, an assistant should separate

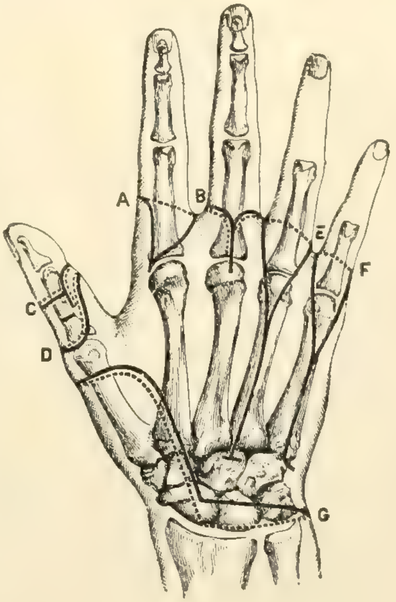

Fig. 121.—Amputations and Disarticulations of the Thumb and Fingers. (From Treves' "Operative Surgery.") *A*, Disarticulation by special externo-palmar flap; *B*, disarticulation by lateral flaps; *C*, amputation by unequal dorso-palmar flap; *D*, disarticulation by oblique palmar flap; *E*, disarticulation of the ring finger, with its metacarpal bone, by racquet incision; *F*, the same operation upon the little finger; *G*, Dubreuil's disarticulation at the wrist.

widely from this the other fingers. The extensor tendons having been divided, the wrist and the condemned finger should be extended and the flexor tendons divided from below by carrying the palmar incision down to the bone. It will now be easy to turn the finger from side to side, deepening each lateral incision, thus severing the digital arteries on either side as well as the lumbricales and interossei muscles. After the flaps have been dissected back, open the joint from below, severing the lateral ligaments. After the glenoid (anterior) ligament has been cut, the finger is removed. The digital arteries should be ligated. Tendon sheaths should be closed. This method produces a vertical cicatrix.

2. *The Equal-Lateral-Flaps Method.*—Because of the ease and speed with which these flaps may be fashioned under certain conditions, as when one is forced to operate without an anæsthetic, etc., this method may be chosen; but it has the disadvantage of opening up the palmar tissues. As before, the point of the blade is inserted into the skin about three-fourths of an inch above the head of the metacarpal bone, and the incision is carried across each lateral aspect of the root to a point on the palmar surface which corresponds to the centre of the base of the proximal phalanx. This procedure will require only two incisions, while the former requires three. Having mapped out these incisions the surgeon severs the tissues down to the bone, opens the joint, and divides the tendons in the manner already described.

The digital arteries will require ligation, the tendon sheaths should be sutured, etc. In every case where strength of the hand is required, the head of the metacarpal bone should be left; but, if the patient especially desires removal for the cosmetic effect, it may be done. The removal should be accomplished by a Gigli-Haertel saw or a fine small Butcher's saw, it not being wise, for reasons already stated (page 274), to use the bone forceps for this purpose.

Amputation of the Index Finger.—It becomes necessary, when amputating this finger, to use a method that will yield a scar on the inner side and away from the thumb. The reason is apparent, since a median cicatrix or one placed toward the thumb would be exposed to pressure from various causes, especially in holding a pen. A satisfactory scar here may be produced (Treves' "Operative Surgery"):

"(*a*) By the racquet incision, with the vertical cut placed upon the side of the index nearest to the middle finger, and with the incision curved a little farther on the radial than the ulnar side of the digit. In the latter situation it corresponds to the web. (*D*, Fig. 118.)

"(*b*) By unequal lateral flaps, the external flap being the larger. (Fig. 120.)

"(*c*) By the externo-palmar flap of Farabeuf. The incision commences at the joint line, just to the radial side of the extensor tendon. It is carried along the outer side of the dorsum nearly as far as the centre of the shaft of the phalanx. It is then made to sweep across the palmar aspect of the finger to the web. From the web it passes by the shortest route to the point at which the incision commenced." (A, Fig. 121.)

Special Operation for the Little Finger.—The same object is held in view in amputating the little finger as when amputating the index, namely, that the scar shall not be exposed to pressure. Hence its location should be internal rather than external. This result may be accomplished by reversing the method described for the index finger, that is, by having the internal flap the larger instead of the external; by making the racquet incision as near as possible like that of the ring finger; and by employing the interno-palmar flap of Farabeuf instead of an externo-palmar flap. (G, Fig. 118.)

Amputations and Disarticulations of the Thumb.—*Surgical Anatomy.*—The thumb has only two phalanges, and receives its blood supply through four digital arteries instead of two, as in the case of the fingers. All of these arteries may require ligaturing. In disarticulating the thumb at the metacarpo-phalangeal articulation the proximity of the radial artery should be remembered; the vessel dips into the palm in the first interosseous interspace. There are four muscles inserted into the base of the first phalanx of the thumb.

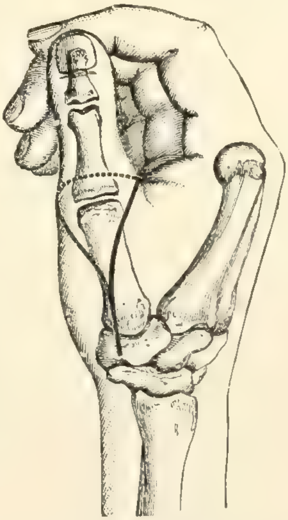
Fig. 122. — Disarticulation of the Thumb with its Metacarpal Bone by a Racquet Incision. (From Treves' "Operative Surgery.")

Amputations through either phalanx, or disarticulations at the interphalangeal joint, may be done by any one of the several operations described for the same purpose in the paragraphs relating to the fingers. Disarticulation at the metacarpo-phalangeal joint of the thumb is best accomplished by:

(*a*) The oval method;

(*b*) The racquet method;

(*c*) The long palmar flap; and

(*d*) The unequal lateral flaps.

The oval method, in the case of the thumb, differs in no respect from the one already described for disarticulation at the metacarpo-phalangeal joint of a finger. The racquet is practically the same as the oval. (See Fig. 121.) The long lateral flap is of advantage when the tissue on the surface alone is fit for use in a flap. The employment of a "U-shaped flap," according to the method of Farabeuf, with its periphery extending to about the middle of the first phalanx, is the best plan to adopt under these circumstances.

If unequal lateral flaps are chosen, it will be well to make the external the longer, as this will throw the scar inward, doing away with the likelihood of pressure. Tendon sheaths should be closed, etc., as in other disarticulations already described.

Amputation through the Metacarpal Bones.—It will sometimes be necessary, though rarely, to amputate through one or more of the metacarpal bones. Tissues of the palmar surface should be utilized for the principal flap if two or more of these bones are condemned. If only one metacarpal is to be sacrificed, then a racquet incision, with the dorsal cut prolonged to the site of the proposed division of the bone, will be useful. The head of the bone should be left if possible, as it adds strength and symmetry to the hand. It also should be remembered that the palmar tissues are exposed and that the chances for infection are thus increased. The bone should be divided by a Gigli, chain, or small bow saw. Care should be taken not to wound the deep palmar arch. It will be well out of the way when the bone is divided at, or beyond, its middle. The synovial sac of the carpus should also be carefully avoided.

Amputation of the Entire Hand at the Wrist. (Figs. 123–127.)—While objections to this operation have been made, there can be no doubt about its success or about the likelihood that a useful stump will be secured in a fair proportion of the cases. Some maintain that amputations at the wrist yield a heavier mortality than do amputations through the lower third of the forearm. This statement, in our opinion, has not been verified. Another objection has been urged, viz., that it is more difficult to provide a satisfactory artificial limb for the stump resulting from this operation than for that which results from amputation at the lower third of the forearm. While this is true to a certain extent, it does not hold good in all cases. Still another objection has been raised, viz., that the stump is slow to heal, owing to the numerous tendons, articulating cartilages, etc., which it contains. If thorough asepsis be maintained this objection also should not be of much consequence. Therefore, although we are not champions of this operation, we feel that there is no sound reason why it should not be performed in suitable cases.

The indications for operation are:

(*a*) Injuries so severe as to make it necessary that not only the fingers be sacrificed but also the rest of the hand.

(*b*) Disease of the carpal bones in cases not suitable for excision of these bones.

(*c*) Gangrene or diffuse suppuration of the palmar tissues.

(*d*) Burns.

(*e*) Cases in which excision has failed.

Surgical Anatomy.—The line of the wrist joint is one-fourth of an inch above a line connecting the styloid process of the radius with that of the ulna. The skin on the dorsum is thinner than that on the palmar surface and contracts more readily. The point of the styloid process of the ulna is on a level with the joint. There are four principal ligaments belonging to this joint—two lateral, an anterior, and a posterior. The anterior annular ligament, though smaller than the posterior, is much stronger. There are six compartments for the various extensor tendons beneath the posterior annular ligament. The superficial palmar arch is formed by the ulnar artery and its anastomosis with the superficialis volæ branch of the radial. This is usually the case, though in rare instances the radialis indicis or the princeps pollicis enters into this anastomosis. The superficial palmar arch is larger than the deep. It gives off the digital branches to the fingers. The line indicating this arch is drawn from the web of the extended thumb across to the ulnar side. The palmar fascia lies over the superficial arch. The deep palmar arch is formed by the radial artery and its communication with the deep branch of the ulnar. This arch is under the flexor tendons on the metacarpal bones, and is one finger's breadth nearer the wrist than the superficial arch.

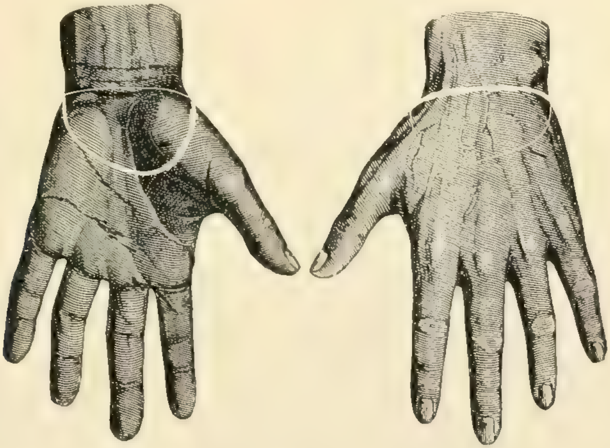

FIG. 123.—Disarticulation at the Wrist. Lines of incision, anteriorly and posteriorly, for the long palmar-flap operation. (Farabeuf.)

Disarticulations at the Wrist.—METHODS.—Several methods are used for removing the hand. The best, as we believe, is either the long palmar flap or the elliptical. Of these methods the following six deserve to be mentioned:

1. Long palmar flap.
2. Elliptical flap.
3. Equal anterior and posterior flaps.
4. Method of Dubreuil. (G, Fig. 121.)
5. Circular flap.
6. Long dorsal flap.

1. *Long Palmar Flap.* (Fig. 123.)—The brachial artery should be secured either by a tourniquet or by the pressure of an assistant's fingers. The condemned hand should be supinated and either supported by an assistant or, better, by a table on which is spread a sterile sheet. After having abducted the thumb so as to put the palmar tissues on the stretch, the operator starts his incision over the styloid process of the radius, carries it on to the thenar eminence, and then sweeps

across the palm, on the level with the superficial palmar arch, to the hypothenar eminence, where the incision turns to pursue a downward direction until it ends at the styloid process of the ulna. The flap having now been outlined, the incision is next deepened, and the flap dissected up in such a manner that it includes not only all the tissues down to the flexor tendons, but also portions of the thenar and hypothenar muscles. If portions of these muscles remain in the flap, the nutrition of the parts will be improved. The hand should now be pronated and flexed and a slightly convex incision should be made between the styloid process of the ulna and the same process of the radius (Fig. 120). The skin thus divided should be dissected up to the joint line. Flexing the hand still further, the operator may open the joint from either side. The ligaments are next divided. The tendons having been cut squarely by a bold circular sweep of the amputating knife, the hand is removed. It is well to leave the articular cartilages unless they are diseased, since, to remove them completely, the bones would have to be divided above their level, thus interfering with subsequent pronation and supination. The tips of the styloid processes of both bones should be sawn off. Care should be used not to open the radio-ulnar joint, and the operator may avoid this by keeping the point of the knife directed toward the carpus. Should this joint, however, be opened, pronation and supination may be interfered with. The radial, ulnar, superficialis volæ, and interossei arteries and one or two of the larger branches of these vessels will have to be ligated. All divided tendons having been trimmed, the open mouths of sheaths having been stitched, suitable drainage having been provided, etc., the wound may be closed.

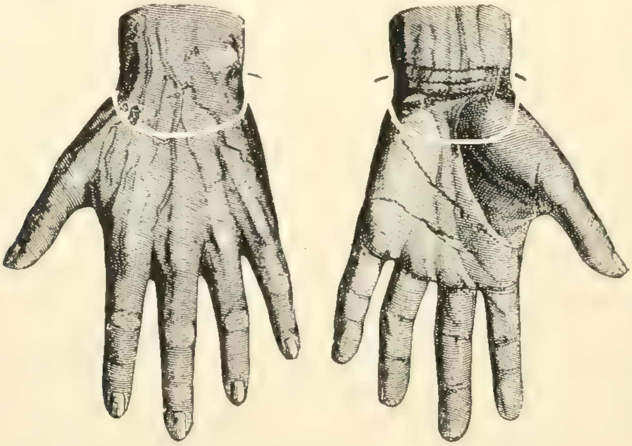

FIG. 124.—Disarticulation at the Wrist. Lines of incision, anteriorly and posteriorly, for the elliptical-flap operation. (Farabeuf.)

2. *Elliptical Disarticulation.* (Fig. 124.)—This method gives good results and provides a covering for the bones in much the same manner as does a long palmar flap. The highest point of the ellipse should be on the dorsal surface of the

hand, to the inner side of the midline and about half an inch below the joint line. The lowest point should be on the palmar surface about two inches below the level of the highest point and in a line with the middle finger. It is best to mark out the palmar part first, the patient's hand being supinated and the incision being commenced on the left side. Pronate the hand and mark out the dorsal part. (Fig. 123.) Deepen the incision, dissect up both flaps as far as to the joint line, flex the hand, and attack the joint from the dorsal aspect as before. Divide lateral ligaments, extensor tendons, and the posterior ligament. Then, with the knife in the joint, cut the anterior ligament and the flexor tendons from within outward. Remove the hand and ligate the radial artery which has been cut in the act of disarticulating, and which will be found in the outer extremity of the wound. The cut end of the ulnar will also require ligation, as may one or two of its larger branches. The open mouths of the tendinous sheaths having been stitched, provide for drainage and close the wound.

In regard to the other four methods no special description is required.

Amputation of the Forearm.—SURGICAL ANATOMY.—The lower third of the forearm presents two nearly flattened surfaces, its shape being due to the scarcity of muscular tissue and the abundance of tendons. In the upper two-thirds both anterior and posterior surfaces are somewhat rounded, owing to the mass of muscular tissue found in this region. On the anterior surface the bundle of muscles is considerably thicker than on the posterior, a circumstance which is of importance in regard to securing flaps. The transverse diameter at this portion of the limb is greater than the antero-posterior. Both radius and ulna lie nearer the posterior surface than the anterior. The arterial supply of the forearm is furnished by the radial, the ulnar, and the posterior and anterior interossei. There are also muscular and collateral branches which require ligation after amputation of the limb. The radial artery extends downward from the bend of the elbow to the front of the wrist, where it passes outward, crossing the wrist joint, to reach the back of the carpus. Its relations in the forearm are as follows:—Externally, it is bounded by the supinator longus and the external vena comes, in the middle third it also has the radial nerve on its outside; in the lower third the nerve is likewise external, although the supinator longus lies between the artery and the nerve. Internally, it is bounded above by the pronator radii teres and below by the flexor carpi radialis. The internal vena comes accompanies the artery throughout its course. In front, it is overlapped slightly by the supinator longus. Behind, it lies, from above downward, upon the tendon of the biceps, the supinator brevis, the radial origin of the flexor sublimis digitorum, the flexor longus pollicis, and the pronator quadratus. The ulnar artery lies beneath the superficial muscles of the forearm. To its inner side lie the flexor carpi ulnaris and the ulnar nerve, in the lower two-thirds of its course. To the outer side, in the lower two-thirds of its course, is the flexor sublimis digitorum. The interosseous arteries run along the anterior and posterior surfaces of the interosseous membrane. If the relations of the radial and ulnar arteries be borne in mind, the ligation of these vessels in the stump will be facilitated. Whenever possible the insertion of the pronator radii teres on the middle of the outer surface of the radius should be preserved. If the arm be amputated above this point, the biceps and supinator brevis will turn the radius outward, and thus the movements of rotation will be abolished.

Since the interosseous space is widest when the forearm is in the position of supination, it should be held in this position when the interosseous membrane is divided.

Methods of Amputation.—The following methods will be described:

1. The circular.
2. The modified circular.
3. The method by equal anterior and posterior flaps.

The method employed will vary according to the part of the limb through which the amputation is performed. For the lower third the circular or modified circular gives the best results, but for the remaining two-thirds, where there is an abundant supply of muscle, either the modified circular or the method by equal anterior and posterior flaps should be employed. For the lower third we prefer the modified circular to the circular, as it does away with the teat-like projection of skin at either angle of the flap which is formed by suturing. These projections, however, promptly disappear after healing.

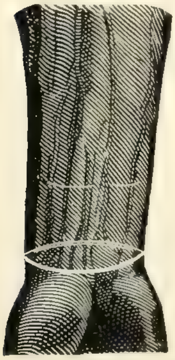

Fig. 125.—Circular Amputation of the Forearm in its Lower Third. The fainter white line above shows at about what level the bones should be sawed across. (Farabeuf.)

The instruments required are a scalpel, an amputating knife, an amputating saw, scissors, from twelve to eighteen hæmostatic forceps, dissecting forceps, curved and straight needles, a three-tailed retractor, and an Esmarch bandage or a tourniquet.

1. *Circular Method.* (Fig. 125.)—The first step is to apply the Esmarch bandage to the arm, or, in case of malignant or septic disease, to hold the limb vertical for a few minutes and then, when it has become bloodless, to apply the tourniquet above the elbow, thus compressing the brachial artery. When this has been done the assistant takes his place to the left of the limb which is to be removed, standing opposite to the surgeon. The first assistant manipulates and steadies the arm and forearm. Other aid in the way of sponging, ligaturing, etc., may be rendered, if necessary, by a second assistant. The line at which the bones are to be sawn is first decided upon. To determine the level at which the skin is to be divided, measure the circumference of the forearm at the line of proposed bone-section and select a point distant one-fourth of its circumference below. Thus, if the circumference of the limb at the line where it is proposed to saw the bone is eight inches, the skin incision should be made two inches below

this line. The circular skin incision may be made with a scalpel, the surgeon cutting carefully and slowly; or it may be made with one sweep of the amputating knife, which is drawn around the limb from heel to point. The experienced surgeon may employ the latter method with safety and precision; the occasional operator, however, will do better to use the former. Skin and fascia should be completely and evenly divided down to the muscles. To facilitate their division the assistant should turn the forearm first in one direction and then in another so as to bring its entire circumference into view. When this has been done the cuff is dissected up as far as the line of bone section. The manner in which the scalpel is held, while this manipulation is being carried out, is important. Its edge should be directed toward, instead of away from, the bones, so as to avoid unnecessary interference with the blood supply of the integuments. The muscles are divided one-half or three-quarters of an inch below the line of bone-section (Fig. 126). This may be done by a circular sweep of the knife, or by inserting it in the flap beneath all the soft tissues, first on one surface of the limb and then on the other, and cutting outward so as to form two short flaps. The tendons should be carefully retracted. The bones are now well cleared, the interosseous membrane divided, the three-tailed retractor applied, and the bones sawn through simultaneously. The blood-vessels are tied with catgut. The arteries requiring ligation are the radial, the ulnar, the posterior interosseous (sometimes also the anterior interosseous), and the artery accompanying the median nerve, as well as certain muscular branches. The nerves are cut off high up, and the cuff of skin is drawn down over the stump and closed with interrupted silkworm-gut sutures. Drainage is employed for from twenty-four to forty-eight hours. The limb is placed midway between pronation and supination and supported on an internal angular splint.

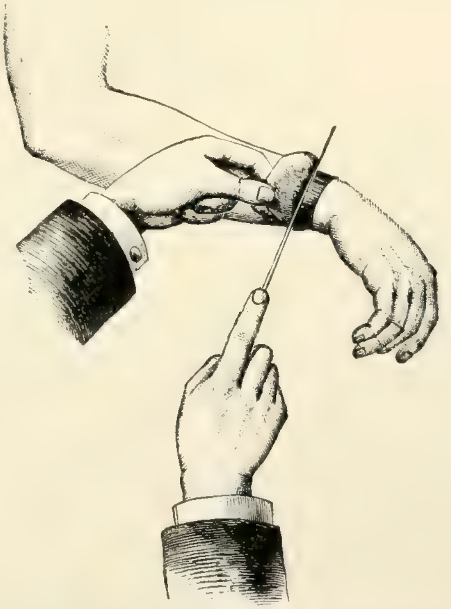

Fig. 126.—Circular Method of Amputating the Forearm—"*Amputation à la manchette.*" (From Treves' "Operative Surgery.")

2. *Modified Circular Method.*—The steps of this method are practically the same as those of the circular method, the only difference being in the manner of making the skin flaps. In regard to the modification, we prefer to adopt Liston's method of making two short semilunar tegumentary flaps instead of adding the vertical incisions to the circular, as shown in Fig. 120. In addition to preventing the formation of the teat-like projections at either angle of the cicatrix,

this method affords a higher exposure of the bones than does the ordinary circular method. The posterior skin flap should be made somewhat longer than the anterior.

3. *Method by Equal Antero-posterior Flaps.*—In amputating through the upper two-thirds of the forearm antero-posterior U-shaped flaps are employed. The base of each flap should be equal to one-half the circumference of the limb at the line of bone-section. Their length should be equal to three-fourths the circumference. When the right forearm is to be amputated the incision is begun on the radial border of the limb; when the operation is to be performed on the left, it is begun upon the ulnar border. (Fig. 125.) The surgeon stands in front of the limb, which is held in a position of supination by an assistant, and outlines the anterior tegumentary incision first and then the posterior, taking care to separate the skin and subcutaneous tissues thoroughly from the underlying muscles. The limbs of the U should not correspond exactly to the lateral margins of the arm, but be slightly removed from them; otherwise a semilunar and not a U-shaped incision will be made. The assistant now flexes the forearm, and holds it vertical while the operator makes the posterior incision uniting the limbs of the U. After the skin has retracted, the arm is held horizontal, but still in slight flexion, and the muscular flaps are cut by transfixion. The amputating knife is introduced first beneath the tissues on the anterior surface of the limb, and is then made to pass as close to the bones and interosseous membrane as possible. As the knife is about to be carried through the tissues, from above downward, the assistant extends the hand and draws the muscles down toward the wrist. (Fig. 127.) The posterior muscular flap is cut in the same manner, the hand, however, being flexed and the muscles pushed upward as they are transfixed. It is more difficult to pass the knife beneath the tissues on the posterior surface than on the anterior, and the left hand as well as the right may have to be used to help insinuate it. After the muscular flaps have been cut and the remaining shreds of muscular tissue and

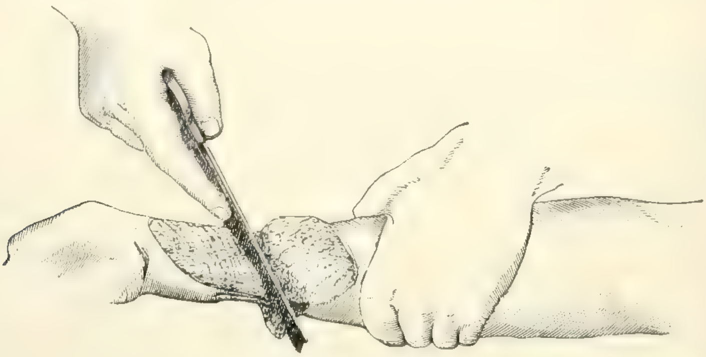

Fig. 127.—Amputation of the Forearm by Antero-Posterior Skin Flaps, with Circular Division of Muscles, etc. (From Jacobson and Steward: "The Operations of Surgery.")

the interosseous membrane divided, the three-tailed retractor is applied; after which the bones are sawn through. The radial, ulnar, and interosseous arteries are now tied with catgut and the nerves are resected high up in the anterior flap. Catgut sutures may be used to secure the muscular flaps over the ends of the bones. The skin flaps are brought down over the stump thus formed, and are united by a series of interrupted silkworm-gut or horsehair sutures. Drainage is employed for from twenty-four to forty-eight hours, when the limb is placed upon a suitable splint and held midway between pronation and supination. The resulting cicatrix is transverse. As already stated, the modified circular method is also applicable to this part of the forearm, and at the present time there is an increasing tendency to employ it. We decidedly prefer it and believe that it is easier of execution, speedier, and adapted to every condition which the surgeon is likely to meet. Moreover, we always avoid, when possible, making flaps by transfixion. The character of the stump which is left after healing has taken place in the modified circular operation, may be judged from the accompanying photograph. (Fig. 130.)

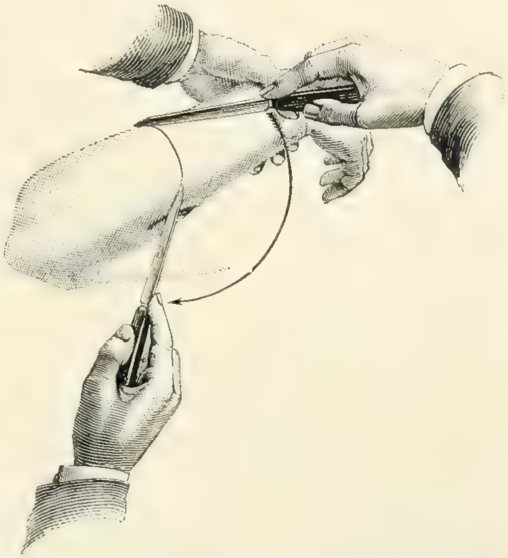

Fig. 128.—Partial Amputation of the Forearm, according to the Double-Flap Method. The posterior incision is made by a single sweep of the knife held in the surgeon's right hand, while his left hand grasps the patient's wrist. In the picture the two attitudes of the surgeon's right hand are represented, viz., that in which the incision is begun and that in which it is about to end. The arrow shows the direction in which the knife moves. (Farabeuf.)

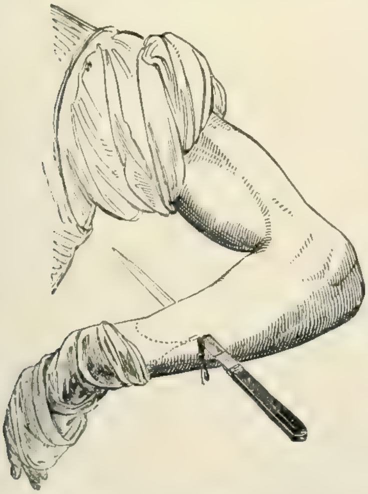

Fig. 129.—Amputation of the Forearm by Transfixion Flaps. (After Fergusson, from Jacobson and Steward: "Operations of Surgery.")

Amputations at the Elbow Joint. (Figs. 131–134.)—Amputation at the elbow joint may be employed for injury, for malignant tumors of the upper portion of the bones of the forearm, for gangrene of the stump after an amputation through the limb, for osteomyelitis, etc. Although the operation has been criticised frequently, there is no doubt that it may be useful in selected cases. If there is enough healthy skin to cover the irregular lower articular surface of the humerus it would seem to be a rational surgical procedure to disarticulate the bones of the forearm instead of sawing away a portion of the humerus. Hemorrhage and exfoliation of the cartilage are imaginary dangers and can no longer be considered valid objections to the operation. The stump is well adapted for the support of an artificial limb. Various methods have been practised in this operation. The essential thing is to secure enough tissue in the flaps to cover the lower end of the humerus effectually, and therefore the method selected will depend more upon the condition of the affected limb than upon any hard-and-fast rule. Thus, when the tissues on the anterior surface of the elbow and upper part of the forearm are intact, a good flap may be obtained by an anterior elliptical incision or by a large U-shaped cut; when the reverse condition obtains, a posterior ellipse may be made. If the tissues on the internal aspect of the joint have been nearly or entirely destroyed, as sometimes happens in cases of severe injury or of gunshot wounds, a flap from the external aspect of the joint may be utilized to meet the defect.

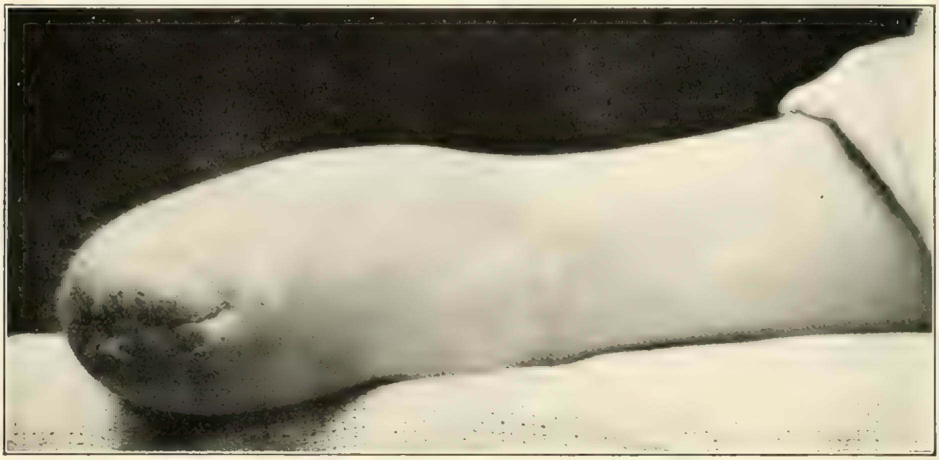

FIG. 130.—Stump after Amputation of the Lower Third of the Forearm. (Author's case.)

Unequal anterior and posterior flaps may also be designed where both of these surfaces have been so injured that neither affords enough tissue to constitute an adequate flap. In a word, the method employed may be varied a great deal according to the good judgment and ingenuity of the surgeon, who will endeavor to save the upper arm in its entirety whenever possible. And, too, the saving of the insertions of the brachialis anticus and the triceps muscles by sawing the bones below the points of insertion adds vigor to the stump. At the same time some advantage is gained in this respect by saving the olecranon process.

SURGICAL ANATOMY.—The bones entering into the formation of the elbow joint are bound together by the capsular ligament, which becomes thickened at the sides to form the external and internal lateral ligaments. These two are the only ligaments of importance so far as amputations are concerned. The external lateral ligament is attached above to the external condyle of the humerus, below to the orbicular ligament. The internal lateral ligament is attached above to the internal condyle of the humerus. Below, it divides into two parts, the anterior of which is attached to the inner margin of the coronoid process, the posterior to the inner margin of the olecranon. In disarticulating it is better to divide the external and lateral ligaments before attacking the internal, as the latter is better divided when the relaxation secured by division of the former permits the forearm to be forcibly extended and turned inward. In regard to the muscles in the vicinity of the joint it should be remembered that only those of the forearm can be utilized in securing a flap. Care should be taken, however, to divide them as low down as possible, and particularly to separate the triceps completely from the olecranon when it is not advisable to save it. The brachial artery usually divides into the radial and ulnar at a point opposite the neck of the radius; but anomalous division of this vessel is not uncommon. Close to its point of origin the ulnar gives off the common interosseous, which at once divides into its anterior and posterior branches. The common interosseous will thus be included in the posterior part of the anterior flap. The posterior ulnar recurrent, together with the superior profunda at the outer condyle and the interior profunda at the inner condyle, may also require to be ligated. In regard to the joint-line, it may be said that inspection of the elbow will enable one to determine it without difficulty, as the anterior crease at the elbow lies just above it. The joint-line itself is not transverse throughout its entire extent, its humero-ulnar portion being oblique. For this reason it will be found easier, when disarticulating, to insert the knife at the horizontal humero-radial portion and separate it before attacking the humero-ulnar part. The characteristics of the skin over this joint are also of importance. That on the anterior surface is very retractile, so that much more than is actually required to cover the stump must be available if an anterior flap is to be employed. That on the posterior surface retracts less.

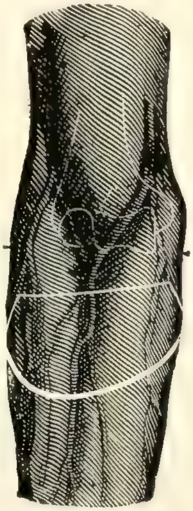

Fig. 131.—Anterior Aspect of the Right Elbow. Lines of incision employed in the operation for disarticulation when it is decided to make a fairly long anterior flap with a broad base. At its inner end this base is distant a finger's breadth from a line connecting the two condyles; at its outer end the distance amounts to the breadth of two fingers. (Farabeuf.)

Methods.—The methods here described are:

1. The anterior elliptical flap.
2. The large anterior flap.

3. The posterior elliptical flap.
4. The large external flap.

The instruments needed are a large strong scalpel, an amputating knife, an amputating saw, scissors, a dozen hæmostatic forceps, and curved and straight needles.

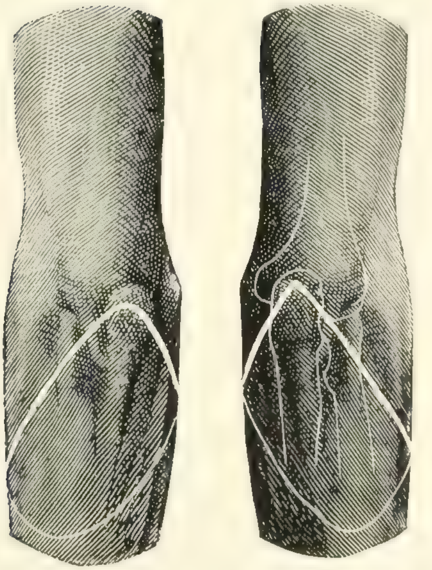

Fig. 132.—Posterior Aspect of the Right and Left Elbows, showing the Outlines of the Elliptical Incision employed in Disarticulation of this Joint. In the right elbow (*R*) the relations of the underlying bones to the incision are shown; and attention is called to the fact that here the incision is almost lozenge-shaped. (Farabeuf.)

1. *Anterior Elliptical Flap.*—The limb is held at a right angle to the body by an assistant who stands opposite the surgeon. The incision is begun over the tip of the olecranon process, is carried around to the anterior surface of the forearm, then is curved to the opposite border, and finally is carried obliquely over the posterior aspect to the point where it was first started. This incision involves only the integuments. (Fig. 133.) The forearm is now slightly flexed, and the anterior muscular flap is cut by transfixion, the amputating knife being inserted through the muscles as close to the joint as possible. This cut should be made obliquely. The bones are now freed from the remaining muscular tissue at the joint-line, and disarticulation is begun. The anterior ligament is cut first, next the external lateral, and then the internal lateral. The olecranon is now pulled away from the trochlear surface and the posterior ligament and the fibres of the triceps are divided. The radial and ulnar nerves should be divided high up, the vessels ligated with catgut, and the flap drawn up over the lower end of the humerus and sutured with silkworm gut to the posterior margin of the wound. Drainage should be employed.

2. *Large Anterior Flap.* (Fig. 131.)—The flap is U-shaped, the outer (radial) limb of the U being longer than the inner owing to the greater retractility of the

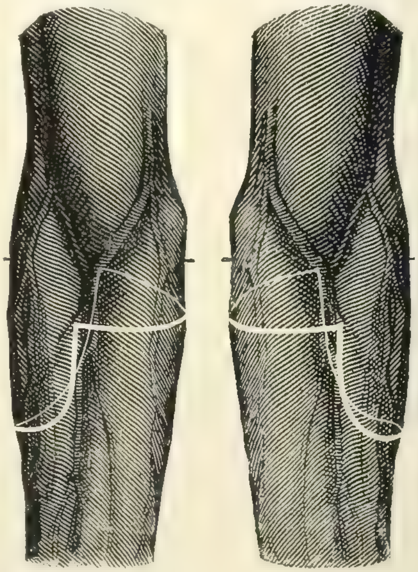

Fig. 133.—Anterior Aspect of the Right (*R*) and Left (*L*) Forearms, Showing Lines of Incision Required in Disarticulating the Elbow. Note how the anterior branch of the U rises to a point considerably lower down than that reached by the posterior branch. (After Farabeuf.)

skin on the outer aspect of the elbow. Farabeuf directs that the base of the U be more than equal to one-half the circumference of the limb. Its length will vary with the condition of the tissues. Less than four inches cannot be considered ample length after allowance for retraction is made. The first incision involves only the skin and should be made with the limb in the supine position and well extended. The posterior incision connects the limbs of the U; its direction should be slightly oblique owing to the difference in length of the two limbs. The integuments are now retracted and the muscular flap cut by transfixion. The remaining steps of the operation are the same as in the method which employs an anterior elliptical flap.

3. *Posterior Elliptical Flap.*—This method differs from that of the anterior elliptical flap in that the ellipse is begun on the anterior aspect of the joint and completed on the posterior surface of the forearm. Thus the flap is formed largely of the thin skin which covers the elbow, the blood supply of which is not so good as that of tissues used in the construction of the anterior elliptical flap. The incision is begun one inch below the internal condyle, is curved upward to the joint-line, and is then carried downward along the external border to a point half an inch below the level at which it was begun on the internal border. (Fig. 130.) The ellipse is now completed by carrying a curved incision around the posterior surface of the forearm and making its lowest point at least three inches below the tip of the olecranon. Ashhurst directs that the anterior bundle of muscles be divided half an inch below the joint-line. In this amputation the brachial artery may be divided above its bifurcation; the superior and inferior profunda will also require ligation. Disarticulation and closure of the wound are effected in the usual manner.

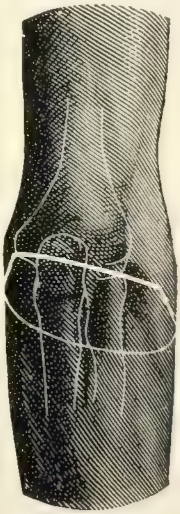

Fig. 134.—Posterior Aspect of the Right Elbow. Lines of incision formerly proposed by Brasdor. Posteriorly the integuments were divided on a level with the joint. (Farabeuf.)

4. *Large External Flap.*—In amputating by the method which calls for a single external flap the forearm is held midway between pronation and supination, and an incision, beginning at about the middle of the radial border, is curved across the forearm and then carried vertically upward on the posterior surface to a point on a level with the joint-line and just external to the olecranon. Another incision, which should begin at the starting-point of the one just described, is carried upward in front of the radius along the internal border of the supinator longus, being terminated about an inch below the joint-line, thus being somewhat shorter than the primary incision. These incisions form a U-shaped flap. (Fig. 133.) The width of this flap should be equal to one-third the circumference of the limb. The limbs of the U are now united by an

incision carried around the internal surface of the forearm. These incisions involve merely the skin and subcutaneous tissue. The muscular flap may be cut by transfixion or from without inward. Disarticulation is effected in the usual manner. The brachial artery and several muscular branches will require ligation. The technique of this method, as here described, is that of Farabeuf, from whose work this description has been taken.

Amputation of the Arm. (Figs. 135 and 136.)—SURGICAL ANATOMY.—The surface markings of the arm are easily recognizable. On the anterior surface the prominence made by the biceps is readily seen, the deltoid can be plainly outlined over the upper portion of the external surface, and its insertion just above the middle of the outer surface of the humerus can also be distinctly felt. The insertion of the muscle marks the point of origin of the brachialis anticus, and is also on a level with the insertion of the coraco-brachialis on the inner surface of the humerus. With the exception of the biceps the muscles are adherent to the bone in the lower half of the arm, whereas, in the upper half, they are fairly free, and consequently retract when divided. The deltoid, however, is not so retractile as the other muscles. Owing to this retractility of the muscles in the upper half of the arm the circular amputation is not applicable in this portion of the limb unless the muscles be divided correspondingly. The blood supply of the arm is derived from the brachial artery, which begins at the lower border of the teres major and passes downward, first on the inner aspect of the arm and then on its front, to a point just below the bend of the elbow. Accordingly, in the upper part of the limb compression of the artery should be made from within outward, but in the lower part it should be made from before backward. This vessel frequently presents anomalies—a circumstance which should not be forgotten. It is accompanied by two venæ comites, one on either side. The superior profunda artery arises close to the beginning of the brachial, and passes downward with the musculo-spiral nerve between the inner and outer heads of the triceps through the musculo-spiral groove to the outer side of the arm. The inferior profunda usually arises from the brachial artery on a level with the insertion of the coraco-brachialis, although it may arise in common with the superior profunda or immediately below it. It passes downward with the ulnar nerve through the internal intermuscular septum to the back of

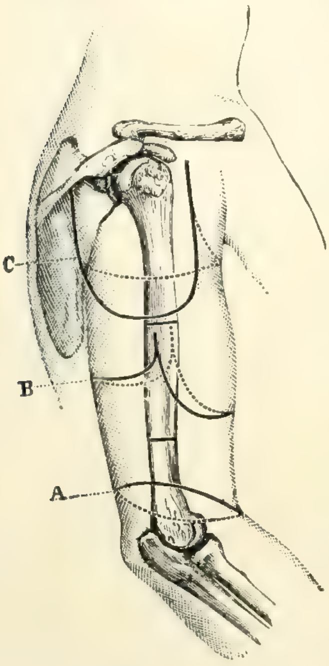

FIG. 135.—Amputation of the Arm. (From Treves' "Operative Surgery.") *A*, Circular (inclined) amputation; *B*, amputation by antero-posterior flaps; *C*, amputation at the shoulder joint by deltoid flap.

the internal condyle. The anastomotica magna is given off from the inner side of the artery about two inches above its termination. There are also numerous muscular branches which may require ligation. The skin on the inner surface of the arm, particularly in the upper two-thirds, is more retractile than that on the external surface.

The instruments required are an amputating knife, two scalpels, an amputating saw, a dozen hæmostatic forceps, dissecting forceps, scissors, needles, drainage tube, blunt hook, and bone forceps.

Methods of Amputation.—The method employed will depend upon the portion of the arm through which the amputation is to be performed. For the lower half the circular amputation is appropriate; for the middle and upper portions the method by anterior and posterior flaps; and, for amputating through the surgical neck of the humerus, either the external flap or the oval method may be used. (See Fig. 135.)

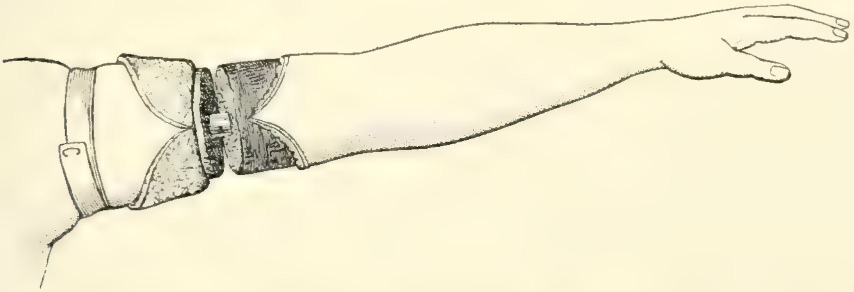

Fig. 136.—Amputation of the Arm. Two crescent-shaped flaps of skin (one external, the other internal) have been made and turned back over the upper part of the arm. (Esmarch.)

1. *The Circular Method.*—In carrying out this method the arm is held horizontal and at a right angle to the body. The skin incision is made with the long amputating knife, which should be so managed as to cut from heel to point, thus encircling about three-fourths the circumference of the limb with a single sweep. To the primary incision thus made a secondary one is added, completing the division of the integuments. After the skin and subcutaneous tissues have been thoroughly freed and retracted, the muscles are divided by a few circular turns of the knife, the flap thus formed is drawn well upward, the retractor is applied, and the bone sawn through. The divided end of the bone is now covered by the flap, which is fastened in position by means of interrupted silkworm-gut sutures. Drainage is employed. The vessels requiring ligation are the brachial, the superior profunda, the inferior profunda, and a number of muscular branches. The modified circular method, with semilunar flaps, may be employed with satisfaction both here and in the middle third of the arm.

2. *The Method in which Anterior and Posterior Flaps Are Employed.* (Fig. 135.) —In amputating according to the method which calls for anterior and posterior flaps two U-shaped flaps are cut, the incision beginning just below the proposed

line of bone section. The length of the anterior flap should be equal to the diameter of the limb, that of the posterior to one-half of its diameter. The first incision involves only the integuments. The muscular flaps are cut either by transfixion or circularly, the former being the classic method. The anterior one should be made a little longer than the posterior, so as to allow for greater retractility of the biceps. (Fig. 135.)

3. **Amputation through the Surgical Neck of the Humerus.**—This amputation is sometimes employed instead of disarticulation at the shoulder joint, and in proper cases it is a better procedure than the latter. It affords a stump suitable for the application of an artificial limb, and does not produce so great deformity as does disarticulation at the shoulder. It should not be performed, however, on persons younger than sixteen years (Treves), owing to the possibility that, through the future growth of the bone from the epiphysis of the humerus, a conical stump may result. When the tissues are in good condition prompt healing may be expected to take place.

In Farabeuf's method of amputating by an external U-shaped flap, the surgeon stands at the outer side of the limb and, retracting the skin with the left hand, outlines the flap by means of an external cutaneous incision which begins an inch below the head of the humerus. The length of this flap should equal the diameter of the limb, the breadth one-half its circumference. Owing to the retractility of the integument on the inner aspect of the arm, the internal incision that unites the upper extremities of the U should be curved downward, instead of being carried transversely across the arm. After the integuments have retracted, the base of the flap is grasped between the thumb and fingers and the deltoid muscle is cut by transfixion from below upward, until the line of bone section is reached. The internal tissues are now cut, the brachial artery first having been ligated. The tendon of the pectoralis major and the adductor muscles should be carefully separated from the bone, but the upper portion of the former may be left intact. The tendon of the biceps is to be divided low down. The flaps are sutured together with interrupted sutures of silkworm gut, and the wound is dressed in the usual manner, drainage being employed.

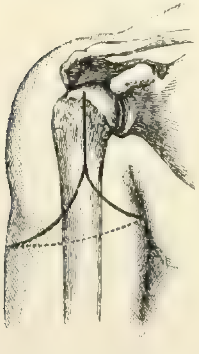

FIG. 137.—Disarticulation at the Shoulder by Racquet Incision—Spence's Operation. (From Treves' "Operative Surgery.")

In amputating by Guthrie's oval-flap method, the arm is raised from the side of the body, and, after compression of the subclavian artery has been made by the fingers of an assistant, or by means of elastic compression, an incision is begun two finger-breadths below the acromion process and carried to the inner side of the arm just below the border of the pectoralis major: then it is extended under the arm to the outside where it is joined by another incision that starts from the point of departure of the original one. These incisions involve only the integument, which is to be well retracted before the muscles are cut. When they have been divided the bone is exposed as high up as the tuberosities, the circumflex vessels and nerves are drawn upward with a blunt hook, and the bone is then sawn through. The wound is closed in the same manner as in the external-flap method.

Amputation at the Shoulder Joint. (Figs. 137–147.)—This operation is required when, as the result of injury or disease, the condition of the tissues in the upper arm is such as to make necessary the sacrifice of the limb in its entirety. The operation is generally performed for a severe injury or for sarcoma. A variety of methods have been devised, but there are a few principal ones which meet nearly every contingency. Where great traumatism has been inflicted, the essential thing is to secure enough tissue to close the defect, and to employ that method which seemingly best meets the indications.

Surgical Anatomy.—The bones entering into the formation of the shoulder joint are the head of the humerus and the glenoid cavity of the scapula. The capsular ligament is attached internally to the margin of the glenoid cavity, and externally to the anatomical neck of the humerus and to the tuberosities. It forms a somewhat lax bond of union between the two bones, and permits of extensive movement. The muscles around the joint form a much stronger investment than its capsule. Above is the supraspinatus; in front, the tendon of the subscapularis; behind, the infraspinatus and teres minor; below, the long head of the triceps. More superficially is the deltoid, which supplies to the joint a superior covering and gives the shoulder its characteristic rotundity. Beneath the deltoid the tuberosities of the humerus can be felt. The acromion process projects above the joint, making a prominence which is easily felt. It is situated about one inch above the glenoid cavity and projects a like distance beyond. The coracoid process bears an important relation to the joint in front, and affords attachment to important muscles related to the movements of the arm. The joint is supplied by the anterior and posterior circumflex, the suprascapular and dorsalis scapulæ arteries, and the acromial branch of the acromiothoracic artery. Of these the posterior circumflex is the most important. It arises from the posterior aspect of the axillary artery on a level with the lower border of the subscapularis muscle, and then, after passing through the quadrilateral space, winds around the surgical neck of the humerus in company with the circumflex nerve. The circumflex nerve animates the deltoid and should for this reason, if for no other, be carefully preserved in excisions. At the under

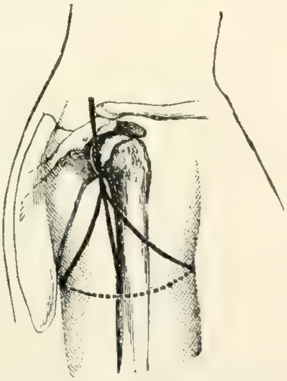

Fig. 138.—Disarticulation at the Shoulder Joint—Larrey's Operation. (From Treves' "Operative Surgery.)

surface of the deltoid it divides into a number of branches. In amputations at the shoulder the axillary vessels will also be divided.

METHODS OF CONTROLLING HEMORRHAGE.—Several methods have been devised for securing hæmostasis during the operation. Thus, the subclavian artery has been compressed against the first rib by the thumb of an assistant or by the handle of a large key, which has previously been well padded. These methods are not trustworthy and should not be employed if better means can be obtained. The finger may become exhausted and relax the pressure, or the key might slip, either of which occurrences would result in most serious hemorrhage. Compression by means of an elastic band passed over the shoulder and under the axilla is not certain, as it also may slip or exert diminished pressure after the operation is well under way. An exception may be made in favor of this method when it is employed in conjunction with Wyeth's pins. According to Wyeth's procedure, one pin is entered at the middle of the anterior axillary fold and is brought out one inch internal to the tip of the acromion process. The other pin is entered at the middle of the posterior axillary fold and is also brought out one inch internal to the tip of the acromion process. The ends of the pins are protected with sterilized corks. (Figs. 139 and 140.) Rubber tubing is wound firmly around the shoulder and axilla above the pins. It is important to pass the pins through the tissues as described, for unless this be done the tubing is likely to slip when disarticulation of the humerus is being accomplished. If much thickening of the

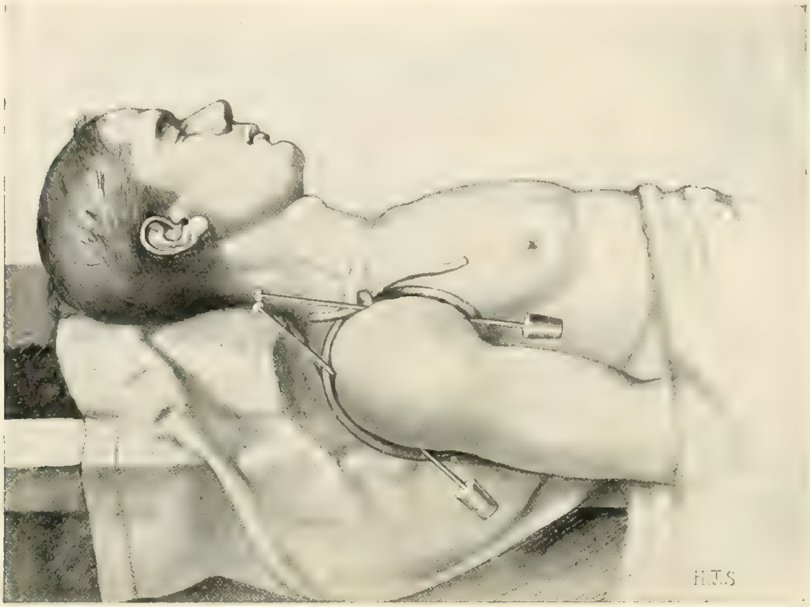

FIG. 139.—Wyeth's Method of Hæmostasis as Applied to an Amputation at the Shoulder Joint. Pins and rubber-tube tourniquet in position. The Esmarch bandage has been removed. (From drawings by H. J. Shannon.) (From "Practice of Surgery," by John A. Wyeth, M.D., LL.D., New York, 1908; by permission.)

tissues has resulted from disease of the joint, even this form of constriction may not suffice. Another, and, according to some, probably the best and safest method of controlling bleeding, is to pick up the axillary artery in the flap and ligate it before severing it. The ligature should be placed below the origin of the posterior circumflex, so as to preserve the latter vessel intact.

The instruments required are an amputating knife, two scalpels, scissors straight and curved, an amputating saw, a dozen hæmostatic forceps, dissecting forceps, curved and straight needles, drainage tubes, and a retractor.

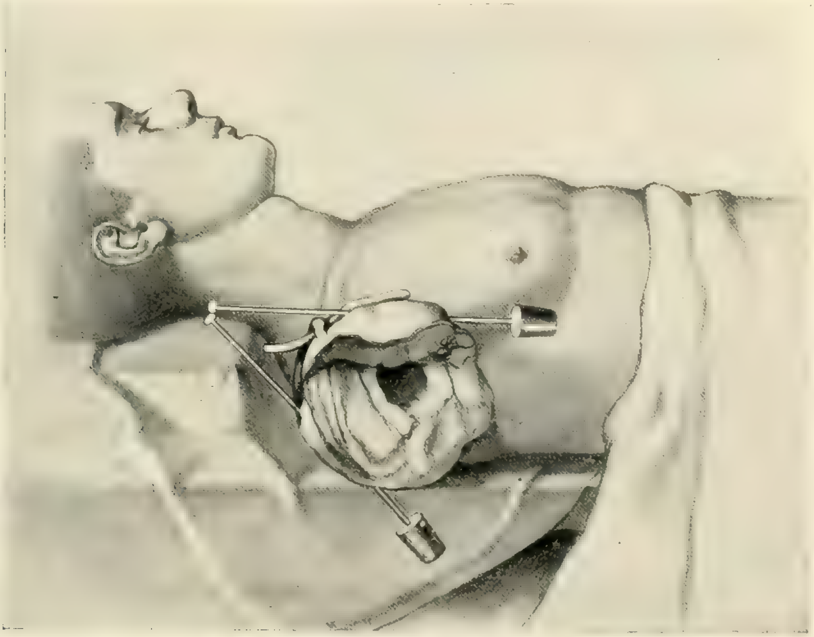

FIG. 140.—The Same after Disarticulation and Ligature of the Vessels. (From "Practice of Surgery," by John A. Wyeth, M.D., LL.D., New York, 1908; by permission.)

METHODS OF OPERATING.—As already stated, a large number of methods have been employed, but many of them are merely of historical interest, and therefore will not be discussed here. Those which will be described are the following:

1. The racquet method (Spence's and Larrey's).
2. The external or deltoid flap method (Dupuytren's).
3. The combined circular and vertical incision.
4. The interscapulo-thoracic method (removal of arm, scapula, and part of the clavicle).

1, *a. Spence's Operation.* (Fig. 137.)—The following is Professor Spence's own description of this operation: "Supposing the right arm to be the subject of amputation, the arm being slightly abducted and the head of the humerus rotated outward, with a broad straight bistoury I cut down upon the head of the humerus, immediately external to the coracoid process, and carry the inci-

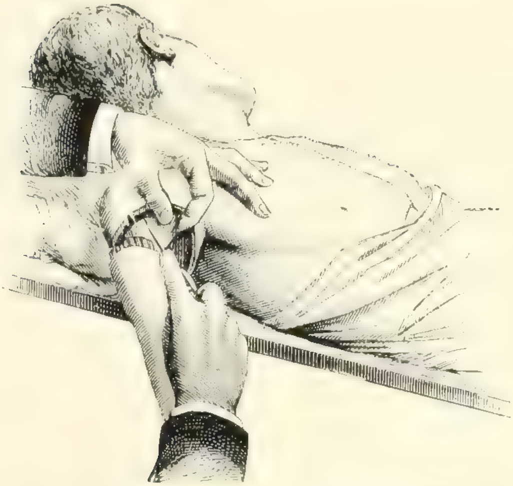

Fig. 141.—Disarticulation of the Right Shoulder Joint; Second Stage. In the illustration the incision of the skin (elliptical or of other shape) has been completed and the anterior fasciculi of the deltoid have been divided (first stage of the operation); with the thumb and forefinger of his left hand, the operator is lifting up the tendon of the pectoralis major, while with the knife in his right hand he is on the point of dividing this tendon close to the point where it is inserted. (Farabeuf.)

sion down through the clavicular fibres of the deltoid and pectoralis major muscles until I reach the humeral attachment of the latter muscle, which I divide. I then with a gentle curve carry my incision across and fairly through the lower fibres of the deltoid, but not through the posterior border of the axilla. Unless the tissues be torn, I next mark out the line of the lower part of the inner section by carrying an incision through the skin and fat only from a point from where my straight incision terminated across the inside of the arm to meet the incision at the outer part. This insures accuracy in the line of union, but is not essential. If the fibres of the deltoid have been thoroughly divided in the line of incision, the flap so marked out, along with the posterior circumflex trunk, which enters the deep surface, can be easily separated from the bone and joint, and drawn upward and backward so as to expose the head and tuberosities by the point of the finger without further use of the knife. The tendinous insertions of the capsular muscles, the long head of the biceps and the capsule are next divided by cutting directly on the tuberosities and head of the bone; and the broad subscapular tendon especially, being very freely exposed by the incision, can be much more readily and freely divided than by the double-flap

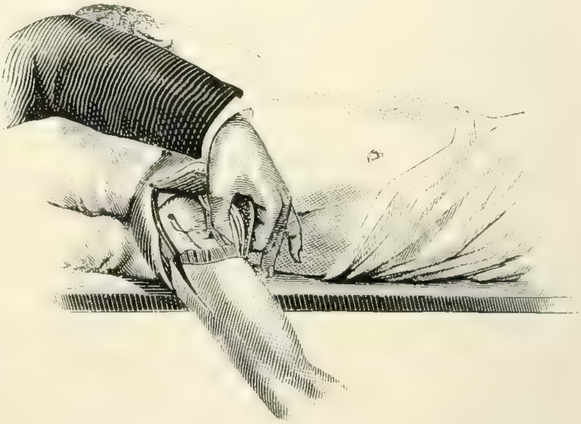

Fig. 142.—Disarticulation of the Right Shoulder Joint; Third Stage. In the illustration the following parts have already been divided: the anterior fasciculi of the deltoid, the tendon of the pectoralis major, and the muscular fasciculus of the coraco-bicipitalis. With his left hand the surgeon is pushing the nerves toward the inner side of the arm and thus exposing the artery, which he is about to ligate. After disarticulation has actually been accomplished the assistant will place his thumb in the same attitude for the purpose of grasping the whole cluster of vessels between it and his forefinger resting against the inner side of the arm. (Farabeuf.)

method. By keeping the edge of the posterior flap out of the way by a broad copper spatula or the fingers of an assistant, and taking care to keep the edge of the knife close to the bone, as in excision, the trunk of the posterior circumflex is protected. The only vessel which bleeds is the anterior circumflex divided in the first incision, and if necessary a pair of catch forceps may be placed on it at once. With regard to the axillary vessels they can either be compressed by an assistant before compressing the soft parts on the axillary aspect, or, to avoid all risk, the axillary may be exposed, tied and divided between two ligatures so as to allow it to retract before dividing the other textures. In cases where the limb is very muscular I dissect up the skin flap from the deltoid at the lower part and then divide the muscular fibres higher up by a second incision so as to avoid redundancy of muscular tissue. The advantages I claim for this plan are: First, the fulness and better form of the stump left after healing. Second, the posterior circumflex artery is not divided except in its small terminal branches in front, whereas, both in the large deltoid-flap and the double methods, the trunk of this vessel is divided in the early stages of the operation, and retracting often gives rise to embarrassing hemorrhage. In the case of the deltoid single-flap method the vitality of the flap must be seriously compromised, as it depends chiefly on that vessel for its arterial supply. Third, the great ease with which disarticulation can be accomplished."

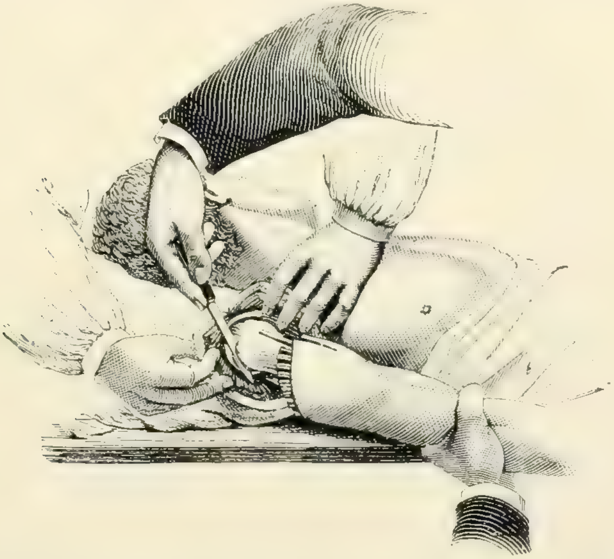

FIG. 143.—Disarticulation of the Right Shoulder Joint: Fourth Stage. The illustration shows the surgeon in the act of dividing the capsule. He has, by dint of some stretching, grasped the patient's elbow (*not* the arm) with his left hand, in order that he may be able at will to turn the humerus on its long axis; while with his right hand, armed with the knife, he has begun to divide the upper part of the capsule of the joint (having previously divided the posterior part). His next step (see Fig. 144) will be to divide the front part of the capsule, but not until he shall have twisted the head of the bone out of its socket. (Farabeuf.)

1, *b. Larrey's Operation.* (Fig. 138.)—The surgeon stands at the outer side of the limb, which is held at an angle of 45° from the body. A vertical incision, beginning just above the extremity of the acromion process, is carried downward for a distance of three inches, dividing all the tissues down to the bone. From the middle of this incision two oblique cuts are made—one on the anterior and the other on the posterior surface of the arm. These incisions should extend to the anterior and posterior borders of the axilla respectively, and their lowest level should be on a line with the lower extremity of the vertical incision. At first, these incisions involve only the integument. The joint is now exposed by deepening these incisions and dissecting up the flaps. (Fig. 141.) In the anterior oblique incision the anterior fibres of the deltoid will be seen, and are to be divided close to the skin incision; the tendon of the pectoralis major is likewise to be divided at its insertion. The coraco-brachialis can now be readily exposed by drawing the flap inward. The next step in the operation is to expose and tie the brachial artery. For the accomplishment of this step Farabeuf's directions cannot be improved upon. He directs that the aponeurosis of the coraco-brachialis be divided by a long cut made with the point of the knife. Through this incision the left index finger is passed, first inward and then behind the muscle, which is lifted up from the humerus and divided transversely. The upper half of the muscle is now retracted and the vessels and

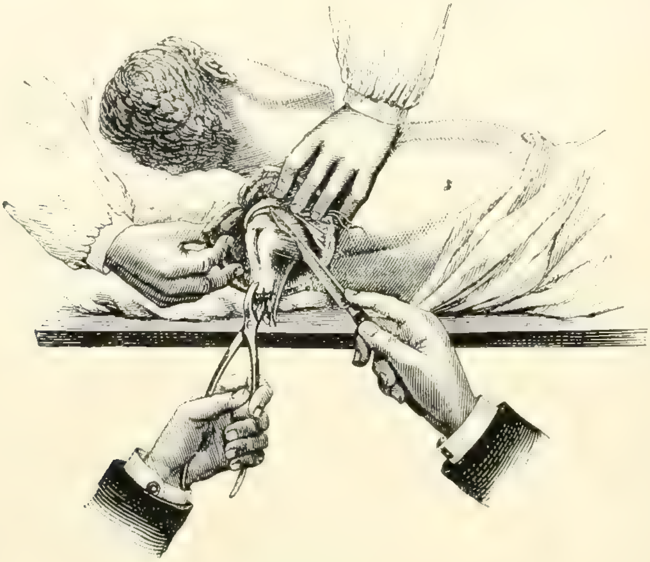

FIG. 144.—Disarticulation of the Right Shoulder Joint; Fifth Stage. The operator, having divided first the left * and then the upper portion of the capsule, is twisting the stump of the humerus to the left while at the same time he is dividing with his knife the right side of the capsule (*i.e.,* the anterior portion of the capsule, if he is operating upon the right shoulder). (Farabeuf.)

* "Left" and "right" in Farabeuf's descriptions of operative procedures refer to things which are on the left or the right side of the operator.

nerves are thus brought into view. The posterior circumflex will be seen entering the quadrilateral space, on a level with the lower border of the subscapularis muscle. The brachial is next tied below it. The posterior oblique incision is then deepened by cutting through the deltoid down to the posterior border of the axilla. (Fig. 142.) The joint can now be readily exposed, and the capsular ligament divided. (Fig. 143.) The limb is seized at the elbow and brought close to the side, so as to expose the superior attachment of the ligament. When this has been done and the ligament has been divided, the humerus is rotated outward, the anterior insertion is divided, and then inward rotation is made and the internal attachment severed. In this manner disarticulation is readily accomplished. Nothing now remains but to unite the extremities of the oblique incisions and thus free the limb completely. The nerves in the stump are cut high up and the wound closed vertically by a series of interrupted silkworm-gut sutures. A drainage tube should be inserted.

2. *Dupuytren's Operation.*—The patient's shoulders should be elevated and the arm held horizontally at a right angle to the body. An incision is begun at the coracoid process and carried downward and outward in a curved direction to the insertion of the deltoid, from which point it is then carried upward (also in a curved direction) and backward until it reaches the junction of the acromion process with the spine of the scapula. This outlines a U-shaped flap. The incision involves only the skin. The muscle is then cut in the line of the skin incision, and the flap thus formed is dissected up. When this has been done the flap is drawn upward by an assistant, so as to bring the joint into view. Disarticulation is effected in the usual manner. A transverse incision dividing the tissues on the inner aspect of the arm is next made. The axillary vessels will be cut by this incision, and should, as a matter of course, be compressed before it is made, and secured as soon as they are severed. In addition to these vessels the posterior circumflex and a number of muscular branches will be divided in the external flap. The wound is closed in the usual manner with a series of interrupted silkworm-gut sutures, and a drainage tube is introduced.

3. *Combined Circular and Vertical Method.*—In this operation the arm is held at a right angle to the body, and a circular incision, begun at the insertion of the deltoid muscle, is carried around it. This incision involves only the skin and subcutaneous tissues. A cuff of skin is dissected up and turned back, and the muscles are divided circularly to the bone at a distance of an inch or an inch and a half above the level of the skin incision. The blood-vessels are secured and tied. Up to this point the operation in every way resembles a circular amputation, with the exception that the bone is left unsawn to act as a lever in the subsequent steps of the operation. A vertical incision is now made on the outer non-vascular aspect of the arm, extending from the circular incision to the acromion process, or preferably the reverse, as it is easier to cut from above downward than from below upward. This incision penetrates to the

bone, which is now cleared internally and externally by careful dissection. The humerus, when it has been freed of all muscular attachments, is used as a lever, is rotated, its capsular ligament is opened, and all attachments are severed—in a word, disarticulation is accomplished. The wound is closed by interrupted sutures which approximate both the circular and the vertical flaps. Drainage should be employed.

For the occasional operator, or when the conditions are such as to make rapid completion of the operation imperative, we consider this operation unquestionably better than any of the others described. It is simple, easy of execution, and offers a certain means of safeguarding against hemorrhage. The stump which results from it, however, is not so shapely as that which is obtained after some other methods.

4. *Amputation Above the Shoulder Joint—the Interscapulo-thoracic Method.* (Fig. 145.)—Removal of the arm together with the scapula and the outer two-thirds of the clavicle may be required for malignant disease (particularly sarcoma) affecting the head of the humerus and the glenoid cavity. The operation may also be required in cases of severe traumatism, particularly such as may be sustained in gunshot wounds. Although the cutaneous incision may require modification, to meet various requirements produced by the nature of the injury, the double-flap method elaborated by Paul Berger may be taken as the model procedure, meeting, as it does, practically all the contingencies which may arise. In this operation two flaps are cut—an anterior-inferior or pectoro-axillary, and a posterior superior or cervico-scapular. The steps of the operation are as follows:

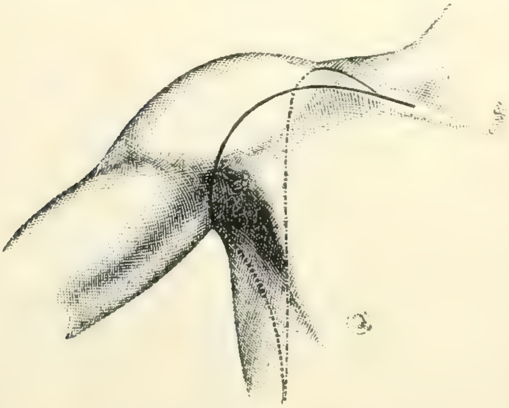

FIG. 145.—Interscapulo-Thoracic Amputation. (From Treves' "Operative Surgery.")

1. Resection of a portion or the whole of the clavicle and ligation of the subclavian vessels.
2. Cutting the anterior flap and severing the brachial plexus.
3. Cutting the posterior flap.
4. Removal of the extremity.

Instruments: amputating knife, large scalpels, hand saw, Gigli saw, chain saw or keyhole saw, bone forceps, lion-jaw forceps, a dozen hæmostatic forceps, dissecting forceps, periosteal elevator, scissors, large needles, curved and straight, blunt hook, and retractors. The patient is placed on his back, close to the edge of the table, and the shoulders are elevated by a cushion placed beneath them.

The shoulder of the affected side should be free from the table. The arm is held a short distance from the trunk by an assistant. The surgeon, with two other assistants, stands at the outer side of the limb, and makes an incision along the clavicle, commencing at the outer border of the sterno-mastoid muscle and terminating just beyond the acromio-clavicular joint. This incision should divide all the structures down to the bone. The periosteum is next divided and raised from the bone with the periosteal elevator—first from the convex surface of the bone, then from the superior surface, and finally, and with great care, from the posterior surface. When this is done, a blunt hook is passed behind the bone, and traction is made upon it by an assistant, who thus pulls it forward so that the surgeon may more readily saw through it. The line of section is at the junction of the inner with the middle third. At first the hand saw may be used, but, to complete the division of the bone, the Gigli, keyhole, or chain saw should be employed. The divided bone is now seized with the lion-jaw forceps and pulled forward, and is again sawn through at the junction of the middle and outer thirds. Any remaining adherent periosteum should, of course, be freed before the second division is commenced. When

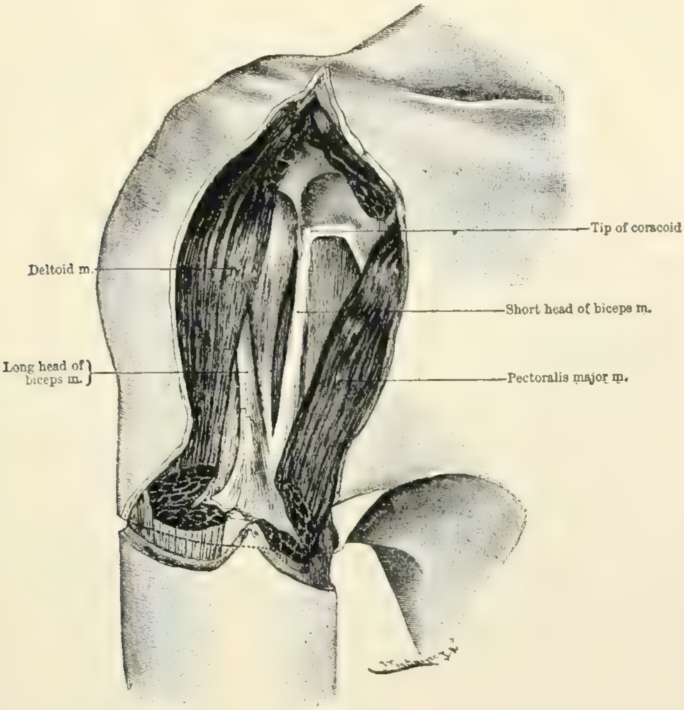

Fig. 146.—Disarticulation at the Shoulder by the Racquet Incision. The incision is made along the anterior edge of the deltoid, commencing above the coracoid process, which is exposed along with the origins of the short head of the biceps and the coraco-brachialis. The anterior border of the deltoid has been divided where it covers the coracoid, and the pectoralis major and deltoid are separated and divided lower down. The long head of the biceps is exposed, along which the incision is carried down to the bone. (From Kocher's "Operative Surgery.")

the middle third of the clavicle is removed the subclavius muscle will be exposed, and is then to be cut away so as to bring the subclavian vessels into view. In case of malignant disease we believe it is better to remove the clavicle in its entirety than to resect the middle third in the manner just described. The vessels are now tied with two ligatures, and are divided between them, the artery being tied first and then the vein. The arm is next abducted, and the operator takes his place at its inner side. He begins an incision at the centre of the clavicular incision and carries it downward and outward, parallel with, but slightly external to, the groove marking the interval between the pectoralis major and deltoid muscles, until he reaches the junction of the arm with the anterior axillary fold, at which point he carries it transversely across the axilla from the tendon of the pectoralis major to that of the latissimus dorsi and teres major. From this point the incision is completed by carrying it downward and inward to the middle of the posterior surface of the angle of the scapula. This extensive incision involves only the skin and subcutaneous tissues. While it is being fashioned an assistant manipulates the arm so as to facilitate the work of the surgeon. The incision is now deepened and the pectoralis major and the pectoralis minor are divided—the former close to its tendon, and the latter near to its insertion on the coracoid process. The brachial plexus is next cut through, and then the shoulder may easily be drawn outward from the body, rendering it easier for the knife, cutting from above downward, to complete dissection. The long thoracic artery should next be ligated and the latissimus dorsi divided. The inferior angle of the scapula, covered with muscles, will then be brought into view. After this has been accomplished, the surgeon will be ready to begin the third step of the operation, viz., to cut the posterior flap. An assistant brings the arm to the side of the body again and lifts up the trunk, so that the operator may fashion his posterior incision. (Fig. 147.) The operator should stand at the outer side of the limb again and trace an incision from the external extremity of the primary clavicular incision downward by the shortest route to the inferior angle of the scapula, making it join the termination of the anterior-flap incision. This posterior incision, which at first involves only the integument, is deepened by rapid dissection until the flap includes all the tissues superficial to the subspinous fossa. The trapezius is freed from the clavicle and the spine of the scapula so that it may be dissected up from the supraspinous fossa. An assistant retracts it, together with the other tissues of the posterior flap. The remainder of the operation consists in freeing the scapula from the trunk. An assistant retracts the flaps and makes pressure at the superior portion of the posterior one so as to occlude, if possible, the posterior scapular vessels. The surgeon, standing at the outer side of the left arm, and to the inner side of the right, makes strong traction upon the member, thereby drawing out the superior and spinal margins of the scapulæ. The muscles retaining the bone —namely, the omo-hyoid, the levator anguli scapulæ, the rhomboids, and the serratus magnus—are now divided. The upper extremity is thus entirely liberated from the trunk. The suprascapular and posterior scapular arteries will require ligation. In the early steps of the operation there is not much bleeding, owing to the fact that the subclavian has been ligated. The flaps formed in this operation are nearly equal in size and have about the same shape. They are to be united by a series of silkworm-gut sutures after drainage has been furnished. Last of all, an abundant dressing is applied and is secured by a firm bandage.*

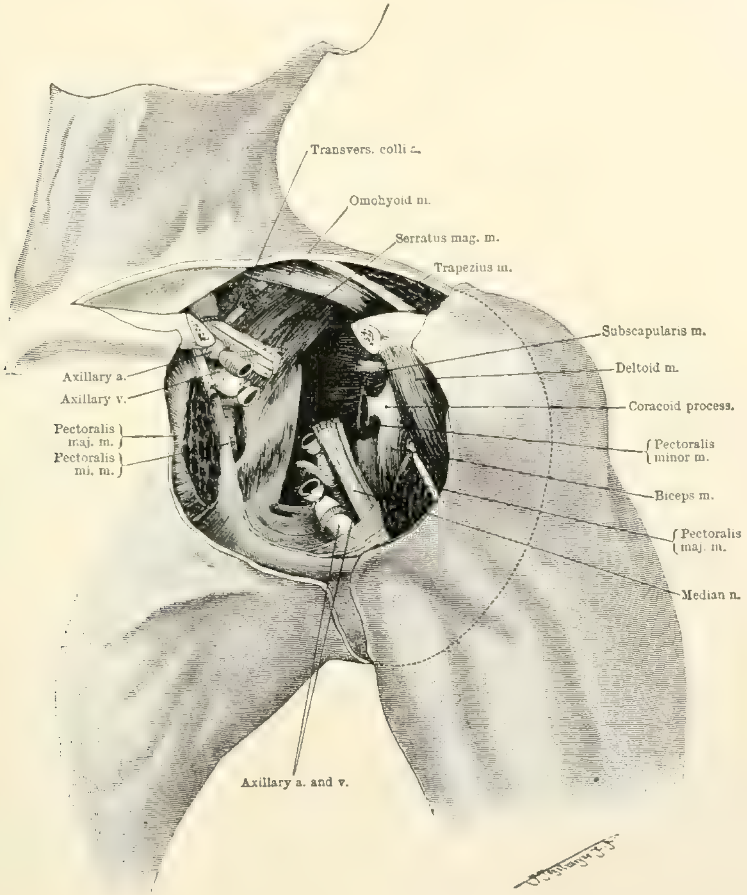

Fig. 147.—Disarticulation of Arm and Shoulder Girdle. Anterior incision, followed by division of clavicle, pectorals, main vessels, and brachial plexus. The chest wall is seen on the left; the anterior aspect of the scapula covered by the subscapularis occupies the floor of the wound. (From Kocher's "Operative Surgery.")

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* LeConte, of Philadelphia, has advised complete excision of the clavicle instead of dividing it at the junction of middle and inner thirds. Certainly his point is well taken in sarcoma of the bones. We also agree with him that it should be as safe as dividing the bone and can, perhaps, be done more quickly. The objection that the large veins are more likely to be injured in a complete excision does not seem, necessarily, well taken.

AMPUTATIONS OF THE LOWER EXTREMITY.

General Remarks.—While the rule of making the most distal operation formerly obtained, the writers believe that at the present day the interests of the patient are just as frequently subserved by departing from this hard-and-fast dictum. The manufacturers of prosthetic appliances have made so many improvements in their specialty that many an amputation formerly practised with reason should now be regarded as obsolete. This is particularly true of many of the amputations of the foot, where the stumps obtained by the "classic" operations of Chopart, Hey, Symes, and Pirogoff are regarded by some surgeons as being inferior to a properly executed amputation in the lower third of the leg. However, prosthetic appliances suited to the preceding operations, especially that of Syme, are extant and are indeed serviceable.

Amputations of the Toes.—In the four lesser toes but little good is accomplished by saving any portion of them in a formal amputation, since the heads of the phalanges are large and may become a detriment to a useful stump. They constitute a comparatively limited supporting force of the foot. In the great toe, however, conditions are entirely different, and no portion of this digit should be sacrificed which can be retained by judicious surgery.

SURGICAL ANATOMY.—The line of the metatarso-phalangeal joints is a curved one, the convexity being directed anteriorly. (Fig. 148.) The metatarso-phalangeal joint of the great toe may be palpated upon the inner aspect of the foot, about one inch behind the web, and that of the third toe is situated at the same level. The corresponding joint of the second toe is one-eighth of an inch in front of the line, that of the fourth toe one-eighth of an inch behind it, and that of the fifth metatarso-phalangeal joint almost half an inch behind it. The knuckles of the toes are formed by the heads of the proximal bones. The metatarso-phalangeal joints are each provided with two lateral ligaments and a glenoid (anterior) ligament. The latter structures are marked upon the plantar surface of the joint and support the heads of the metatarsal bones. These glenoid ligaments are more closely associated with the bases of the first phalanges than with the heads of the metatarsal bones, and are attached to the fibrous sheaths of the flexor tendons of the toes. These fibrous sheaths should be carefully closed whenever divided, to prevent any possible infection. The glenoid ligament of the metatarso-phalangeal joint of the great toe contains two sesamoid bones which rest in grooves upon the head of the first metatarsal bone.

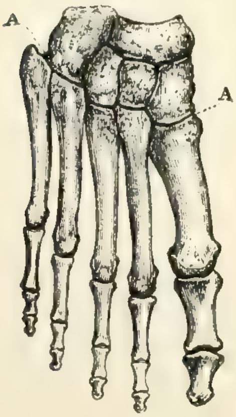


FIG. 148.—Bones of the Foot. (From Treves' "Operative Surgery.") *AA*, Line of Lisfranc's amputation.

The instruments required are stout scalpels with blades from one to two inches in length, a fine keyhole or Butcher's saw, bone forceps, dissecting forceps, hæmostats, tape retractors, scissors, and needles.

Amputation through the Terminal Phalanx of the Great Toe.—This operation should always be performed, if practicable, in preference to disarticulation of the terminal (first surgical) phalanx, since the joint is not trespassed upon nor are the insertions of the flexor and extensor tendons sacrificed. The toe is held between the thumb and fingers of the operator's left hand, the thumb being in contact with the pulp of the toe, and the index and middle fingers resting upon the nail The knife is inserted just in front of the head of the first phalanx (surgical) at right angles to the toe, and a plantar flap is fashioned by cutting around the tip of the toe to a point directly opposite to that of starting, the incision being parallel to the phalanx, rather nearer the dorsal than the plantar surface, and extending down to the bone. If this flap be properly formed the plantar digital arteries will not be divided, but will be retained in the flap together with their anastomoses. While the assistant draws the toe upward (toward the leg), the operator holds the flap with the thumb and fingers of the left hand and dissects it from the phalanx, keeping as close as possible to the bone. The toe should now be flexed and the extremities of the first incision united by a dorsal cut extending to the bone. The latter incision divides the dorsal digital vessels, but these are so small that they usually require no attention. The soft parts are now forcibly retracted and the bone divided, as far back as possible, by a fine key-hole or metacarpal saw. The resulting scar will be situated upon the dorsum of the toe.

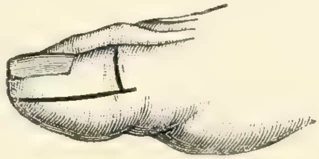


Fig. 149.—Disarticulation of the Last Phalanx of the Great Toe by a Large Plantar Flap. (From Treves' "Operative Surgery.")

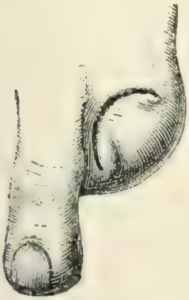


Fig. 150.—Disarticulation of the Great Toe by Internal Plantar Flap: The Resulting Stump. (After Farabeuf, from Treves' "Operative Surgery.")

Disarticulation of the Terminal Phalanx of the Great Toe.—When the preceding amputation is impossible, this operation is performed in an analogous manner, use being again made of a long plantar flap. The toe is held as before, but in making the first incision the knife is introduced a trifle behind and above the head of the second phalanx (surgical). (Fig. 149.) When the flap is reflected the knife should hug the bone, to avoid wounding the plantar digital vessels which are in immediate proximity to the plantar aspect of the interphalangeal joint. When the glenoid ligament is reached it should be divided at right angles by cutting toward the base of the terminal phalanx. In this way the joint is opened. The toe should next be flexed, and upon the dorsum there should be made a transverse incision which divides the extensor tendon and enters the articulation. The toe is now extended and the internal lateral ligament divided, and the member then drawn inward to facilitate the division of the external lateral ligament. Both of these structures should be divided from without inward to avoid wounding the plantar digital vessels. As before, the resulting cicatrix will be placed upon the dorsum of the toe.

In neither this nor the preceding amputation should the plantar flap be made by transfixion, since this procedure endangers the vessels and renders the accurate formation of the flaps impossible.

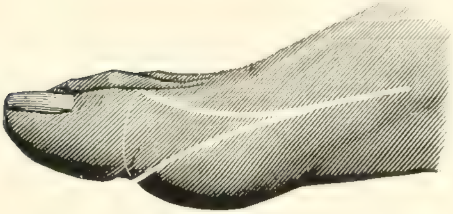


FIG. 151.—Amputation of the Great Toe together with a Part of the Corresponding Metatarsal Bone. Long, racquet-shaped incision on the inner aspect of the foot. (Farabeuf.)

Disarticulation of the Great Toe at the Metatarso-phalangeal Joint. (Fig. 150.)—The best method of disarticulation is undoubtedly that by means of an internal flap (Farabeuf), since the wound left by this operation drains well and since the cicatrix is most advantageously placed. It is well to save the base of the last (surgical) phalanx, if possible, since the muscles attached here materially strengthen the sole of the foot. The surgeon should be seated to the inner side of the foot. Grasping the toe with the thumb and fingers of the left hand he should make the incision through the skin only, commencing at the metatarso-phalangeal joint, at the junction of the dorsal and internal surfaces of the digit, and continuing the incision along the inner side of extensor tendon to a point near the interphalangeal joint. The incision is now carried downward over the internal to the plantar surface, which it traverses in a slight curve to a point near the web, the toe being drawn inward while the plantar incision is being made. The knife is next introduced at the dorsal surface of the web and the incision is completed by cutting in a straight line to the point of starting. The incision is now deepened throughout, directly down to the bone. The flexor tendon should be divided as high up as possible, and this is best accomplished by forcibly extending the toe while the plantar incision is deepened. The soft parts are then dissected away, great care being taken that the knife hug the bone. When the glenoid ligament is exposed it should be divided transversely upon the base of the last (surgical) phalanx, thus opening the joint. The ligament, with the sesamoid bones, should be left in the stump. The amputation is completed by dividing the lateral ligaments and the extensor tendon. The sheath of the flexor tendon should be carefully closed by one or more sutures of fine catgut.

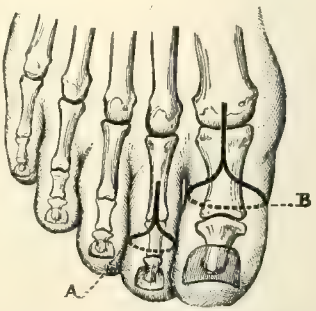


FIG. 152.—Amputation of Toes. (From Treves' "Operative Surgery.") *A*, Disarticulation of the second phalanx of a toe by the racquet or oval incision; *B*, disarticulation of the great toe by the racquet or oval incision.

The two plantar digital arteries should be secured; one will be found in the web, while the other is at the extremity of the flap.

Disarticulation of any of the Lesser Toes at the Metatarso-phalangeal Joints.—The racquet incision is the one usually employed. The adjacent toes should be retracted by the assistant with sterile tapes or bandages. The surgeon, seated directly in front of the foot, grasps the toe with the thumb and fingers of the left hand and inserts the knife almost half an inch behind the metatarso-phalangeal joint, in the median line of the dorsal surface. The incision is carried directly forward to the centre of the last (surgical) phalanx and then encircles the toe to form the racquet, the convexity of which should be just behind the web. The joint should be opened from the plantar surface by cutting through the glenoid (plantar) ligament in the manner described in the previous sections relating to amputations. The sheath for the flexor tendons should be closed in the usual manner.

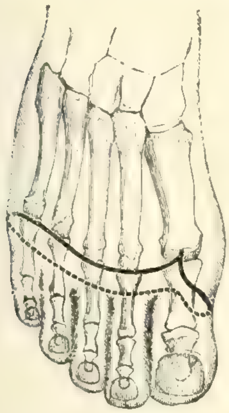
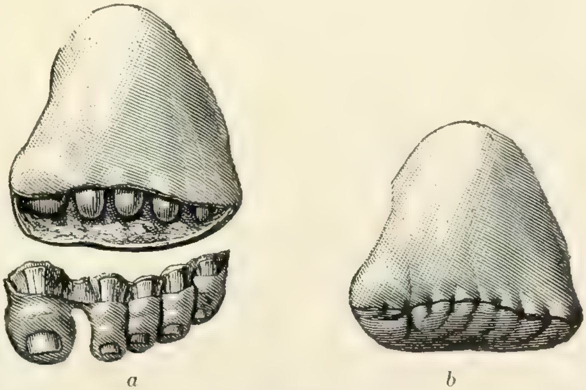


FIG. 153.—Dubreuil's Operation for the Removal of All the Toes. (From Treves' "Operative Surgery.")

In disarticulating the little toe the handle of the racquet should be placed to the inner side of the extensor tendon, so that the cicatrix shall be well out of the way and protected by the fourth toe.

In disarticulating two contiguous toes the handle of the racquet should be placed between them. The toes are disarticulated separately, the tendon sheaths closed, and the wound sutured in the usual manner.

Disarticulation of all the Toes at the Metatarso-phalangeal Joints. (Figs. 153 and 154.)—The importance of this operation is almost wholly of a theoretical nature. It is rarely called for in actual practice and it is difficult to provide a flap of sufficient size to cover the large head of the first metatarsal bone. The best method is that which calls for short dorsal and long plantar flaps, although Dubreuil advocates an additional U-shaped flap from the inner side of the great toe. With the foot everted, the incision is commenced just over the metatarso-phalangeal joint of the great toe and carried directly forward, midway between the plantar and dorsal surfaces, until the middle of the first (anatomical)



a b

FIG. 154.—Simultaneous Disarticulation of All the Toes of One Foot. (After Farabeuf.) *a*, Condition of the stump after the flaps have been pressed down over the gaping wound; *b*, condition after the flaps have been stitched together.

phalanx of the great toe is reached. The assistant now extends the foot and flexes the toes slightly while the operator continues the incision transversely over the dorsum of the first (anatomical) phalanx of the great toe and then follows the line of the web, successively separating the contiguous toes with the fingers of the left hand until the dorsum of the little toe is reached, when the incision is carried backward along the outer margin of the little toe to terminate at the metatarso-phalangeal joint. (Fig. 153.) The dorsal flap thus outlined is now dissected back, the assistant manipulating the toes and thus leaving the surgeon's left hand free to hold the flap, which should contain all of the tissues down to the extensor tendons. When half of the flap has been raised the extensor tendons should be divided, the assistant successively extending each toe to facilitate the division of each tendon at the highest point. The dissection should be continued until the metatarso-phalangeal joints have been exposed. The operator then holds the toes extended and makes the plantar flap by joining the distal extremities of the two lateral incisions by a transverse cut which follows the creases between the toes and the sole, exposing the flexor tendons. The assistant now takes charge of the toes and, when half of the plantar flap has been dissected back, he extends them to enable the operator to divide the flexor tendons high up. The dissection of the soft parts is continued until the line of the joints has been exposed. The flaps are now strongly retracted, the joints are opened upon the dorsum, and the lateral ligament of the joint upon the operator's right side is divided. The toes are next extended and the joints opened upon the plantar aspect, care being taken to preserve the glenoid (plantar) ligaments. Complete disarticulation is now effected from right to left.

After the sheaths of the flexor tendons have been closed by sutures of fine catgut, the plantar digital arteries in the plantar flap are ligated. The dorsal digital arteries in the dorsal flap rarely require attention.

Amputation of All the Toes together with the Heads of the Metatarsal Bones.—Although this amputation partly removes the anterior supporting points of the foot, it is frequently demanded in surgical practice and is a most useful procedure. The best method is that which utilizes a long plantar and a short dorsal flap. The line of section of the metatarsal bones should be a curved one, approximately parallel with the line of the web.

The surgeon sits in front of the foot, which he maintains in a position of forced flexion with his left hand. In operating upon the left foot he inserts the knife at the inner margin, midway between the plantar and dorsal surfaces, just behind the point of proposed division of the first metatarsal bone. The incision is carried directly forward until it reaches the crease between the great toe and the sole, and then curves across the sole just behind the web until the outer surface of the little toe is reached. From this point it is continued directly backward, midway between the plantar and dorsal surfaces, and terminates at a point just posterior to the site of the proposed division of the fifth metatarsal bone. The assistant now takes charge of the foot, which is still maintained in a position of forced flexion, and the operator uses his left hand to hold the flap, which he dissects backward. As soon as the dissection has been well started, the flexor tendons should be divided as high up as possible, this step being facilitated by the assistant, who forcibly extends the toes. The plantar flap should contain all the tissues down to the bones.

With the foot extended, a short dorsal flap is now fashioned by making a dorsal incision parallel with the plantar cut and about one inch in advance of its termination. All the tissues are included down to the bone, and the extensor tendons are divided as soon as the dissection of the flap has been well commenced. The interossei muscles, embracing the metatarsal bones, are now cleanly divided at the sites of proposed section and the flaps retracted well out of the way. Each bone should then be separately divided from the dorsal aspect by a narrow saw, the line of section of all the bones being made parallel to the line of the web. The four plantar digital arteries in the plantar flap opposite to the interosseous spaces should now be secured by ligatures. The plantar digital vessel to the inner side of the first metatarsal bone and the one to the outer side of the fifth metatarsal may also require attention. The corresponding vessels in the dorsal flap should next be inspected, but the only one usually requiring a ligature is the first dorsal interosseous artery which is divided opposite to the first interosseous space.

Partial Amputations of the Foot.—Under this head will be considered the disarticulation of the great toe and little toes, with their respective metatarsal bones; Lisfranc's amputation with its modifications; Chopart's amputation; Syme's amputation; and Pirogoff's amputation with its modifications.

DISARTICULATION OF THE GREAT TOE, TOGETHER WITH ITS METATARSAL BONE.—The instruments required in this operation are the following: One stout knife with a blade three inches in length, a scalpel, narrow retractors, lion-jaw forceps, dissecting forceps, hæmostats, scissors, and needles.

The lanceolate or racquet incision should be employed. (Figs. 151 and 155.) The first tarso-metatarsal joint will be found one inch in advance of the tubercle of the navicular bone. The toe is grasped in the left hand and the knife is inserted at the inner border of the foot just anterior to the line of the tarso-metatarsal joint. The incision is carried upward and outward until it reaches the centre of the dorsal surface of the metatarsal bone. It is then continued directly forward in the median line of the dorsum and to the inner side of the tendon of the extensor proprius hallucis. At the middle of the metatarsal bone the cut gradually slopes to the web; it then traverses the plantar surface in the groove between the toe and the sole and finally curves around the outer surface of the toe to join the dorsal incision at the middle of the metatarsal bone. The dorsal incision is now deepened and the tendons of the extensor pollicis longus and extensor brevis digitorum are divided close to the tarso-metatarsal joint. The soft tissues are next to be separated from both sides of the bone, particular care being taken not to wound the communicating branch of the dorsalis pedis artery, which passes between the first and second metatarsal bones to reach the sole. This dissection is greatly facilitated by the assistant who manipulates the toe, thus leaving the left hand of the operator free to push aside the tissues. While the assistant extends the toe, the surgeon cuts the flexor tendons and clears away the tissues from the plantar aspect of the bone until the joint is well exposed. The sesamoid bones remain in the stump. The joint is now opened from the dorsum and also upon the outer and inner sides. The operator again takes the toe in his left hand, divides the strong plantar ligament and any fasciculi which have previously escaped, and frees the bone by dividing the tendons of the peroneus longus and tibialis anticus. The sheath of the flexor tendon is closed by fine catgut sutures, the tendon having been first retracted high up. The arteries requiring attention are: the dorsal digital branches of the first interosseous in the dorsal incision and the termination of the internal plantar, the first plantar digital, and the internal digital branch to the great toe in the plantar aspect of the wound. Unless great care is exercised the communicating branch of the dorsalis pedis will be wounded between the first and second metatarsal bones. This operation is rarely called for in practice.

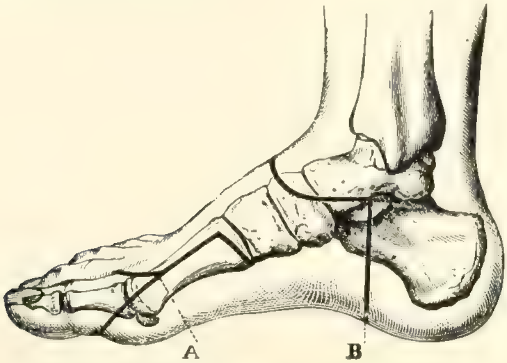


Fig. 155.—Partial Amputations of the Foot. (After Treves). *A*, Disarticulation of the great toe, together with its metatarsal bone, by the oval or the racquet incision; *B*, subastragaloid amputation by heel flap.

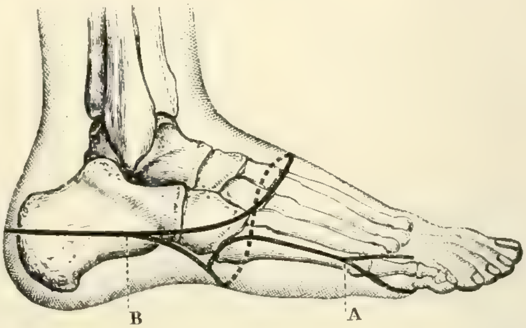


Fig. 156.—*A*, Disarticulation of the Little Toe, together with its Metatarsal Bone, by the Oval or Racquet Incision; *B*, Maurice Perrin's subastragaloid amputation. (From Treves' "Operative Surgery.")

Disarticulation of the Little Toe, together with its Metatarsal Bone. (Fig. 156.)—The lanceolate or racquet incision should be employed. The tarso-metatarsal joint of the little toe will be found immediately behind the prominent tuberosity of the fifth metatarsal bone. The toe is grasped in the left hand, the knife is inserted at the outer margin of the foot, almost half an inch behind the tuberosity of the fifth metatarsal bone, and the incision is carried upward in the line of the cubo-metatarsal joint. Upon reaching the median line of the metatarsal bone the surgeon continues the incision forward as far as the neck of the bone, where an oval flap is fashioned as in the preceding operation. The incision is deepened and the operator proceeds in the same manner as in disarticulating the first metatarsal bone. The outer tendon of the extensor digitorum longus is divided at the highest point of the dorsal incision, in which situation a portion of the extensor digitorum brevis is also visible. The soft tissues are cleared from both sides of the bone, the tendons of the peroneus tertius and brevis are divided, and the joint between the cuboid and the fifth metatarsal bone is opened from the dorsum, as is also the joint between the bases of the fourth and fifth metatarsal bones. The plantar aspect of the bone is then cleared and disarticulation completed by dividing the plantar ligament as well as several strong fasciculi of the plantar fascia. The dorsal digital arteries are cut by the dorsal incision, the plantar digitals are divided in the plantar portion of the wound.

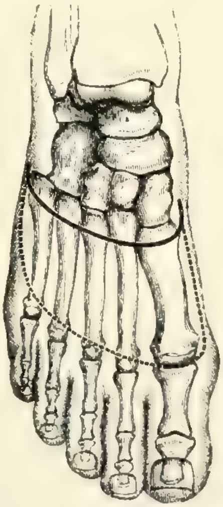


Fig. 157.—Lisfranc's Amputation. (From Treves' "Operative Surgery.")

This operation is rarely called for in practice.

Disarticulation of Two Toes, together with Their Metatarsal Bones.—This is similarly accomplished by the racquet method, the handle of the racquet being placed between the two bones.

Disarticulation of the Second, Third, or Fourth Toe, with Its Respective Metatarsal Bone.—These operations may be performed by the racquet method. They are infrequently employed, but should be considered in order to familiarize the student with the anatomical requirements relating thereto.

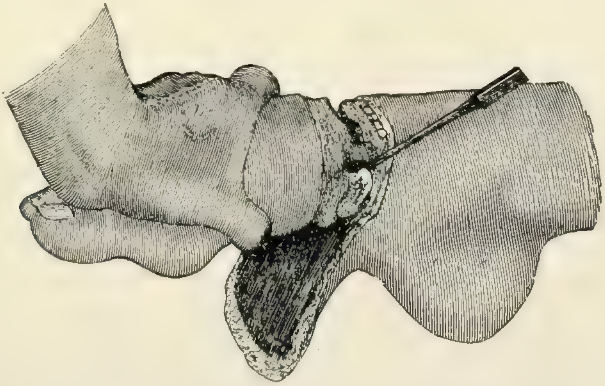


Fig. 158.—Disarticulation of the Second Metatarsal in Lisfranc's Amputation of the Foot. The knife is being used to separate the second from the first metatarsal bone. (From Jacobson and Steward: "Operations of Surgery.")

Disarticulation of the Anterior Portion of the Foot at the Tarsometatarsal Joint (Lisfranc's Operation). (Figs. 157–162.)—*Surgical Anatomy.*—The line of the tarso-metatarsal joints is quite irregular, but it may be regarded in general as a curved one, the convexity being directed anteriorly. The curve starts at the inner margin of the foot, at the first tarso-metatarsal joint, one inch in advance of the tubercle of the scaphoid, and terminates at the outer margin of the foot, at the fifth tarso-metatarsal joint, which is located by the prominent tuberosity of the fifth metatarsal bone. For all practical purposes it may be assumed that the first, third, fourth, and fifth joints are in this line. The second tarso-metatarsal articulation, however, lies back from this line, and this anatomical detail should be well fixed in the mind of the operator. The five metatarsal bones articulate, with the three cuneiform bones and with the cuboid bone, in the following manner: the first metatarsal articulates with the internal cuneiform by a reniform facet, and occasionally with the second metatarsal bone by an indistinct facet; the second metatarsal articulates with the three cuneiforms, with the third metatarsal, and occasionally with the first metatarsal; the third metatarsal articulates with the external cuneiform and with the second and fourth metatarsals; the fourth metatarsal articulates with the cuboid, with the external cuneiform, and with the third and fifth metatarsals; the

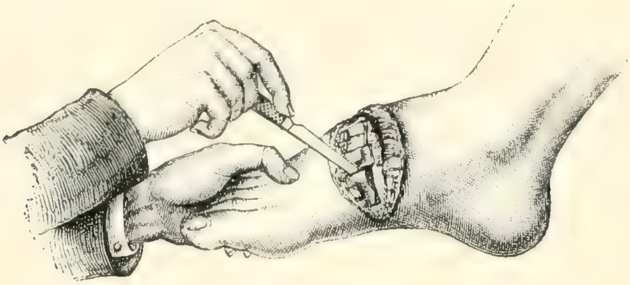


Fig. 159.—The *Coup de Maître* in Lisfranc's Amputation; first step. (After Guérin, in Treves' "Operative Surgery.")

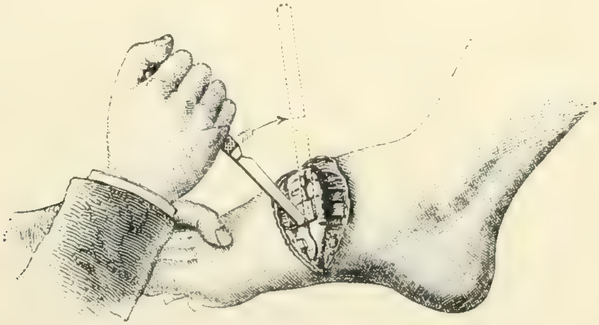


Fig. 160.—The *Coup de Maître* in Lisfranc's Amputation; second step. (After Guérin, in Treves' "Operative Surgery.")

fifth metatarsal articulates with the fourth metatarsal and with the cuboid bone. Mr. Henry Morris groups these numerous articulations into three separate tarso-metatarsal joints, as follows:

1. *The Inner Tarso-metatarsal Joint.* (Fig. 148.)—This is situated between the internal cuneiform and the base of the first metatarsal and is lined by a synovial membrane which is separate from those of all the other joints. The capsular ligament is much thickened below and to the inner side. 2. *The Middle Tarso-metatarsal Joint.*—This joint, which is situated between the three cuneiform and the second and third metatarsal bones, is provided with dorsal ligaments, strong plantar ligaments, and one interosseous ligament. The latter structure (Lisfranc's ligament) in the form of a very strong fasciculus, which extends from the outer surface of the first cuneiform to the inner surface of the base of the second metatarsal, subdivides the joint. It renders the disarticulation of the second metatarsal quite difficult and is severed in the step known as the "*coup de maître.*" The synovial membrane is an anterior extension from that which lines the naviculo-cuneiform joints and the outer cuneiform articulations. 3. *The Cubo-metatarsal Joint between the Cuboid and the Fourth and Fifth Metatarsal Bones.*—It is provided with dorsal, plantar, and interosseous ligaments. The synovial membrane also extends between the bases of the fourth and fifth metatarsals.

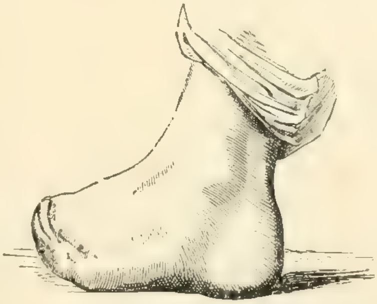


Fig. 161.—Stump After Lisfranc's Operation. (After Fergusson, from Jacobson and Steward: "Operations of Surgery.")

Each metatarsal bone has a single epiphysis. In the four outer ones it forms the head, but in the first metatarsal it constitutes the base of the bone. These epiphyses unite with the shafts between the ages of eighteen and twenty.

The base of the first metatarsal bone receives the attachment of the peroneus longus and some fasciculi of the tibialis anterior. The base of the fifth metatarsal bone receives the peroneus brevis and peroneus tertius. The plantar arch runs obliquely across the joint between the bases of the fourth and fifth metatarsals, and then passes over the bases of the second and third metatarsals somewhat in advance of the tarso-metatarsal joints.

The Lisfranc Operation. (Figs. 157–162.)—The instruments required for this procedure are a stout narrow knife with a blade four or five inches in length, a scalpel, a saw, a narrow spatula, dissecting forceps, hæmostats, retractors, scissors, and needles. The patient should be in the dorsal position with the foot well beyond the edge of the table and at the level of the operator's neck when he is seated. The operator stands while cutting the dorsal flap, but sits facing the sole of the foot when fashioning the plantar flap and during the completion of the disarticulation.

It being assumed that the right foot is the subject of the operation, the surgeon holds the member in an extended position with his left hand, his thumb being upon the base of the fifth metatarsal, his index finger upon the base of the first and his palm in contact with the sole. The dorsal integument is put upon the stretch and the knife is introduced at the plantar aspect of the outer margin of the foot, immediately behind the tuberosity of the fifth metatarsal. The incision is carried forward along the outer margin of the foot for about an inch, and then curves inward across the dorsum, passing about half an inch in front of, and parallel with, the line of the tarso-metatarsal joints. It should strike the plantar aspect of the inner margin of the foot half an inch in front of the first tarso-metatarsal joint, should then follow the internal margin, and terminate three-quarters of an inch behind the articulation. The assistant now maintains the foot in extension, thus allowing the surgeon to use his left hand to assist in raising the dorsal flap. When about a quarter of an inch of the integument has been raised, the extensor tendons are divided and the flap is made to contain all of the soft parts down to the bones. (Fig. 158.) The dissection should be carried back until the tarso-metatarsal joints are freely exposed. Although this is called the "dorsal" flap, particular care should be taken to include as much as possible of the tissues of the inner and outer margins of the foot. (At this stage of the operation surgeons formerly disarticulated and obtained the plantar flap by transfixion.) The surgeon now sits facing the sole and holds the foot in the flexed position with his left hand, the thumb being beneath the toes, and the fingers resting upon the dorsum. The knife is inserted at the plantar aspect of the outer margin of the foot, at the commencement of the dorsal cut, and the incision is carried along the plantar edge of the fifth metatarsal for a short distance. It then curves obliquely along the neck of the fourth metatarsal, sweeps across the sole just behind the necks of the metatarsal bones, and, following the plantar edge of the metatarsal bone of the great toe, terminates at the inner end of the dorsal incision. The inner extremity of the plantar flap should be longer than the outer. The assistant again takes charge of the foot by grasping the toes and holding them in a position of forced extension. The operator next raises the plantar flap, which consists only of skin and subcutaneous tissue, until the hollow behind the heads of the metatarsals is well exposed. The tense flexor tendons are divided by firm transverse cuts. The remainder of the flap

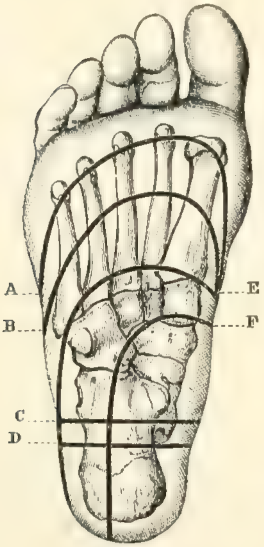


Fig. 162.—Plantar Incisions. (From Treves' "Operative Surgery.") *A*, Lisfranc; *B*, Chopart; *C*, Pirogoff; *D*, Syme; *E*, Farabeuf's subastragaloid amputation; *F*, Farabeuf's amputation at the ankle.

should include all of the tissues down to the bone, and the dissection should be continued until the tendon of the peroneus longus is reached. This tendon indicates the line of the tarso-metatarsal joints and is not to be divided until the disarticulation has been completely effected.

The operator now stands up and extends the foot with his left hand while the assistant retracts both the dorsal and the plantar flaps well out of harm's way. The disarticulation is commenced by inserting the knife just behind the tuberosity of the fifth metatarsal, and cutting obliquely forward and inward, thus opening the tarsal joints of the three outer metatarsal bones and simultaneously dividing the tendons of the peroneus brevis and peroneus tertius. The joint between the first metatarsal and the internal cuneiform is next opened in a similar manner, the incision simultaneously dividing some of the radiating fasciculi of the tibialis anticus. The joint between the second metatarsal and the middle cuneiform is now located (it will be found nearly a half-inch behind the tarso-metatarsal joint of the great toe) and opened upon its dorsal aspect. The most difficult portion of the operation, the division of the ligament of Lisfranc, now follows and is accomplished by what has long been known as the "*coup de maître*." (Figs. 159 and 160.) The knife is held like a trocar, at a slight angle with the dorsum of the foot and with the cutting edge toward the ankle. The point is forcibly thrust between the bases of the first and second metatarsals until it impinges against bone. The knife is then held like a dagger and the handle elevated until it stands at a right angle to the dorsum of the foot. During this manœuvre the cutting edge should be directed toward the external malleolus. The remaining plantar ligaments are then divided, and the completely disarticulated metatarsus freed by drawing out the peroneus longus tendon and dividing it as high up as possible in the outer angle of the wound.

In the left foot the incisions are commenced upon the inner side of the foot, and the disarticulation is accomplished in the reverse order.

Four dorsal interosseous arteries are divided in the dorsal flap, as is also the communicating branch of the dorsalis pedis as it passes toward the sole between the bases of the first and second metatarsal bones. The plantar digital branches of the plantar arch and the termination of the internal plantar artery should be secured in the plantar flap. The plantar arch itself may be wounded near the base of the second metatarsal bone. A small drainage tube should be placed at either angle of the wound, but it is not retained for more than twenty-four hours.

This operation gives a well-formed and useful stump. (Fig. 161.) It is one of the "classic" operations which deserves to survive, although it is frequently impossible in practice, owing to the lack of sufficient tissue to form the plantar flap.

Hey's modification of Lisfranc's operation is generally thought to consist of sawing through the projecting end of the internal cuneiform instead of disarticulating the first metatarsal. It is objectionable since it sacrifices more of the insertion of the tibialis anticus and lessens the leverage of the foot.

Skey's modification consists in sawing across the base of the second metatarsal and allowing it to remain in the mortise of the cuneiform bones. The remaining fragment is almost certain to undergo necrosis.

Bauden's modification is to disarticulate the first metatarsal bone and saw off the remaining ones at the level of the internal cuneiform.

R. W. Smith's modification consists in the division of the four outer metatarsal bones close to their tarsal extremities with a small saw, and the retention of the first metatarsal. The flap is obtained entirely from the sole. This modification preserves two important anterior points of support—the ball of the great toe and the tuberosity of the fifth metatarsal bone; it also adds to the leverage of the foot and interferes less with the transverse arch than does any one of the other modifications. This plan is especially indicated in severe crush injuries.

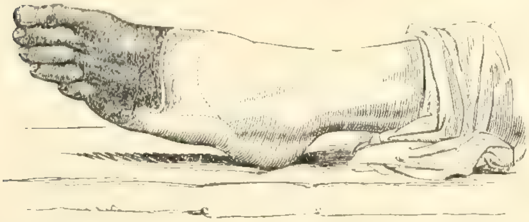


FIG. 163.—Chopart's Amputation of the Foot. The dotted line shows where the incision is to be made, but it errs in making the dorsal flap larger than it should be. The correct size is shown in Fig. 164. (After Fergusson, from Jacobson and Steward: "Operations of Surgery.")

DISARTICULATION AT THE MEDIO-TARSAL JOINT (Chopart's Operation). (Figs. 156, 162, 164, 165, 166, 175.)—*Surgical Anatomy.*—The medio-tarsal joint is composed of the astragalo-scaphoid and calcaneo-cuboid articulations, which are situated practically in the same transverse line and are provided with separate synovial membranes. The astragalo-scaphoid articulation is situated at the inner side of the foot just behind the tuberosity of the scaphoid. It is an arthrodial joint, the globular head of the astragalus being received in the concave posterior surface of the scaphoid. The joint is supported by the thin superior astragalo-scaphoid ligament extending from the neck of the astragalus to the superior surface of the scaphoid, the thick inferior calcaneo-scaphoid ligament extending from the sustentaculum tali of the calcaneus to the under surface of the scaphoid and assisting in the formation of the socket for the head of the astragalus and the superior calcaneo-scaphoid ligament. The latter fasciculus is ≺ shaped; it arises in the deep hollow between the astragalus and the calcaneus and blends with the two preceding ligaments as it passes forward. The lower limb of the ≺, turned over on its side, is formed by the internal calcaneo-cuboid ligament, which is the chief bond of union between the first and second rows of the tarsal bones.

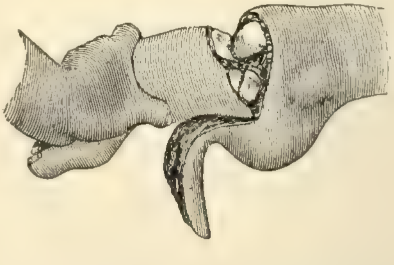


FIG. 164.—Chopart's Amputation of the Foot; Second Stage. (From Jacobson and Steward: "Operations of Surgery.")

The synovial membrane of this articulation is directly continuous with that lining the anterior calcaneo-scaphoid joint. The calcaneo-cuboid articulation is situated at the outer side of the foot about one inch posterior to the tuberosity of the fifth metatarsal bone, or, still better, midway between the line of the external malleolus and the tuberosity of the fifth metatarsal. The articulating surfaces are concavo-convex. The joint is provided with two dorsal and two plantar ligaments. The dorsal ligaments are the previously mentioned strong internal calcaneo-cuboid and the broader superior calcaneo-cuboid. The plantar ligaments are the long and short calcaneo-cuboid. The scaphoid receives about one-half of the insertion of the tibialis posterior.

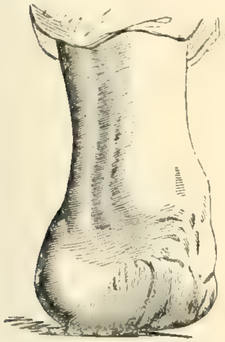


FIG. 165.—Stump after Chopart's Operation. (After Fergusson, from Jacobson and Steward: "Operations of Surgery.")

The instruments and the positions of the patient and operator are the same in the Chopart as in the Lisfranc operation. It being assumed that the right foot is the subject of the operation the surgeon holds the member in the extended position with his left hand, his palm being in contact with the sole. The knife is introduced midway between the tip of the inner malleolus and the tuberosity of the scaphoid and the incision is carried forward along the inner margin of the foot for a short distance. It then curves across the dorsum, crossing the bases of the metatarsal bones, passes backward along the outer margin of the foot, and terminates just behind the tuberosity of the fifth metatarsal bone. The plantar incision follows the general lines of the plantar flap in Lisfranc's operation, joining the extremities of the dorsal incision. It traverses the foot in front of the middle of the metatarsus, and the inner extremity of the flap should be longer than the outer. (See Fig. 162.) Both flaps are raised as in Lisfranc's operation, and the medio-tarsal joint should be well exposed. When disarticulation is performed, the foot is held in a position of talipes equinovarus. Care should be taken not to open the scapho-cuneiform joint, thus leaving the scaphoid behind. Although this plan has been recommended in order to preserve part of the insertion of the tibialis posticus, the modification has not been found advantageous in practice, since the stump is injured rather than helped by the preservation of this muscle. The dorsal flap contains the dorsalis pedis artery, its metatarsal and tarsal branches, and both saphenous veins. The plantar flap contains the internal and external plantar arteries and the digital branches of the latter. Small drainage tubes may

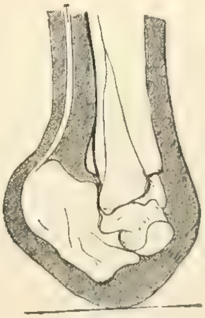


FIG. 166.—Diagrammatic Antero-Posterior Section of Stump often Seen after a Chopart's Operation. It shows the shape of the stump, the position of the bones, and the influence of the tendo Achillis. (After Farabeuf, from Jacobson and Steward: "Operations of Surgery.")

be introduced at either angle of the incision, and removed at the end of twenty-four hours.

Chopart's operation has no established place in modern surgery. The heel is soon drawn up by the tendo Achillis, so that the patient walks upon the sharp anterior edge of the calcaneus: in other words, the stump left by this operation is apt to be painful and useless. Tenotomy of the tendo Achillis does not fully remedy this defect, and still further weakens the part. A little reflection shows that when the arch of the foot is divided at the highest point it can not be maintained by a single posterior support, but is bound to fall under the influence of superincumbent weight.

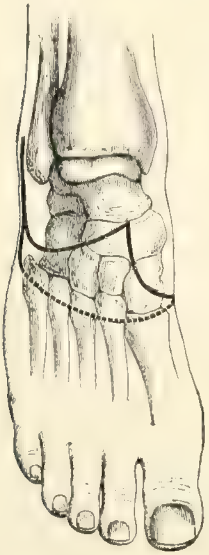


FIG. 167.—Tripier's Operation. (From Treves' "Operative Surgery.")

Forbes's operation consists of disarticulating at the scapho-cuneiform joint and sawing through the cuboid at this level. It has all the disadvantages of Chopart's operation, and the objectionable contraction of the tendo Achillis is reinforced by the preservation of the tibialis posterior.

TRIPIER'S OPERATION. (Fig. 167.)—Tripier sought to obviate the tilting of the heel stump by making a horizontal section of the calcaneus in order to provide the stump with a broad level base. The knife, in this operation, is introduced at the outer side of the tendo Achillis, at the level of the tip of the external malleolus, and the dorsal incision is carried forward one inch below the malleolus. It sweeps a finger's breadth behind the tuberosity of the fifth metatarsal, and terminates at the inner side of the extensor proprius hallucis, two fingerbreadths in front of the ankle joint. The plantar incision starts here, passes over the internal cuneiform bone at the inner side of the foot, crosses the sole as far as its outer margin at the base of the fifth metatarsal, and terminates at the commencement of the dorsal cut. The flaps are raised until the medio-tarsal joint is exposed, and the dissection of the plantar flap is continued until the sustentaculum tali is laid bare. Disarticulation having been next effected, the periosteum is elevated from the entire under surface of the calcaneus, which is seized with lion-jaw forceps and turned outward. The calcaneus is sawn horizontally from within outward, just below the sustentaculum, and the angle between the sawn and cuboid surfaces of the bone is rounded off with the saw. It does not seem that this operation has been extensively performed. We believe that a patient in whose case this operation might seem suitable would be better off were his leg amputated in the lower third and a modern prosthetic apparatus fitted to the stump.

SUBASTRAGALOID DISARTICULATION.—*Surgical Anatomy.*—In this disarticulation the line of separation passes through the astragalo-scaphoid and astragalo-calcaneal joints, the astragalus being the only tarsal bone left in the stump.

A description of the astragalo-scaphoid articulation has been previously given under Lisfranc's operation (p. 320). The astragalo-calcaneal articulations are two in number, the anterior communicating with the astragalo-scaphoid joint, while the posterior one is entirely independent. The two joints are separated by a deep groove in both bones, at least one inch in breadth, which serves for the attachment of the powerful interosseous ligament. The surface of the astragalus, as seen in the stump, is flat and forms a good base for the superincumbent weight. In addition to the interosseous ligament the external calcaneo-astragaloid, the superior calcaneo-scaphoid, and the middle fasciculus of the external lateral ligament of the ankle afford support to the joint. The posterior and internal calcaneo-astragaloid ligaments strengthen the respective aspects of the joint, which also receives additional support from a portion of the deltoid ligament.

The instruments required and the position of the surgeon are the same as in Chopart's operation.

Disarticulation, with a Heel Flap. (Fig. 155.)—The operator and the patient being in the same position as in Lisfranc's operation, the foot is held at right angles to the leg, and the point of the knife is introduced half an inch below the external malleolus. The incision is carried directly downward to the plantar aspect of the heel, which it crosses, and finally terminates one inch below the internal malleolus. A U-shaped flap is now fashioned from the dorsum of the foot, the convexity of the flap being directly over, or slightly in advance of, the astragalo-scaphoid joint. Both flaps should include all the tissues down to the bone. The heel flap is first dissected back, and the tendo Achillis is then divided. The astragalo-navicular joint is well exposed by raising the dorsal flap, and at the same time the assistant flexes the leg upon the thigh and maintains the foot in a horizontal position with its outer surface upward. The operator next turns the foot inward so that its outer surface is put upon the stretch, and then opens the astragalo-scaphoid joint from the dorsum. The knife is kept between the bones and is made to cut backward between the calcaneus and astragalus so as to divide the strong interosseous ligament. As the fibres of the ligament are incised and the tendons to the outer side divided, the various positions of the foot are exaggerated by the left hand of the operator, and all tissues are cleared from the lower and inner surfaces of the bone. When the foot has been completely disarticulated, the heel flap being retracted well out of harm's way by the assistant, the dorsum should be directed downward. Any remaining bridges of tissue are now divided and the foot freed. The head of the astragalus should be sawn off. Ashhurst, who preferred this method of subastragaloid disarticulation to all others, disarticulated at the medio-tarsal joint and then twisted the calcaneus from side to side with a lion-jaw forceps while he separated it from the astragalus.

The arteries divided in the flap are essentially the same as those divided in Syme's operation (see p. 329). A hole should be made in the centre of the heel flap, and into this a short drainage tube should be introduced. This tube is to be removed at the end of twenty-four hours.

This method is easier than that of any of the procedures which we are now about to describe. The wound heals well, as the soft parts are not easily disturbed. The objections to the method are the narrow stump which is left and the proximity of the scar to the pressure area.

The Racquet Operation of Maurice Perrin. (Fig. 156.)—This procedure is difficult of execution, and the vessels of the flap are considerably endangered during the progress of the operation. The tissues do not heal as kindly as in some of the other operations, since they must necessarily be rather roughly handled. When the operation is successful, however, the resulting stump is broad and the scar is well out of the way of pressure.

The knife is introduced at the insertion of the tendo Achillis and the incision is carried forward, parallel with the outer border of the malleolus, to a point just behind the base of the fifth metatarsal. It then curves across the dorsum and strikes the inner border of the foot at the level of the joint between the internal cuneiform and first metatarsal bones. The incision is finally carried outward across the sole and terminates in the first incision, about two inches behind the base of the fifth metatarsal bone. Disarticulation is effected exactly as in the preceding operation. The head of the astragalus should be sawn off.

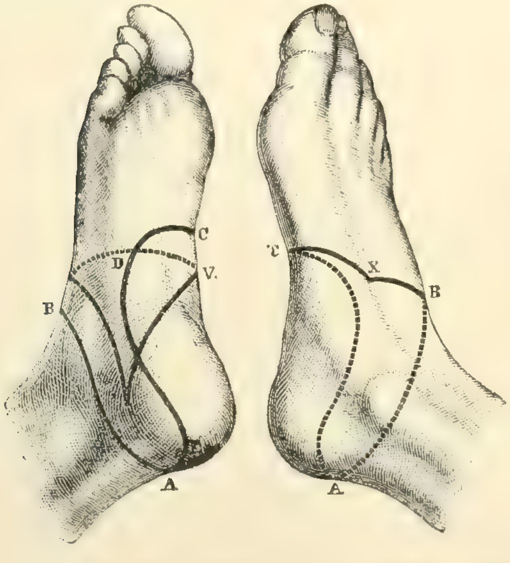


Fig. 168.—Inner and Outer Sides of the Right Foot, to Show the Incisions in Farabeuf's Subastragaloid Amputation. (From Treves' "Operative Surgery.") *A*, Point where incision is begun; *B*, *X* and *C*, points to which it is next carried; in its subsequent course it crosses the sole of the foot (*C* to *D*), then follows the outer border of the foot to the os calcis (*E*), and terminates at the point of beginning (*A*). (See also Figs. 162 and 169.) *V*, The lines of Verneuil's subastragaloid amputation.

The Operation of Verneuil. (Fig. 168.)—This operation is a modification of the oval method. The knife is introduced over the outer tubercle of the calcaneus and about two or three centimetres below the tip of the external malleolus. The incision passes forward to a point two centimetres behind and to the inner side of the base of the fifth metatarsal, from which point it is carried across the dorsum of the foot to the centre of the internal cuneiform bone. It finally terminates by passing in a direct line to the point of starting. The flap includes all the tissues down to the bone. Disarticulation is effected in the usual manner, and the head of the astragalus is sawn off.

This is a simple method, but it is open to the serious objection that the flap is not large enough.

Farabeuf's Operation.—The distinguishing feature of this operation is the employment of a large internal and plantar flap. (Figs. 168 and 169.)

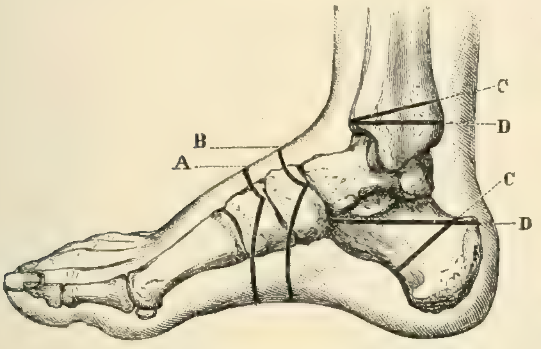


Fig. 169.—*A*, Farabeuf's Subastragaloid Amputation; *B*, Farabeuf's amputation at the ankle joint; *C*, *C*, saw-cuts in Pasquier and Le Fort's operation; *D* shows also the saw-cut made in the os calcis in Tripier's operation. (From Treves' "Operative Surgery.")

Lignerolles, who first proposed subastragaloid disarticulation in 1839, employed two lateral flaps, while Lisfranc used a single dorsal flap, and Malgaigne took a single flap from the inner part of the plantar surface. Nélaton fashioned dorsal and plantar flaps which were larger on the inner than on the outer side. The stump after subastragaloid disarticulation is possibly more useful than that of either Syme's or Pirogoff's operation, owing to the preservation of the ankle joint.

Although agreeing with Treves and Ashhurst that the heel-flap method is the best for subastragaloid disarticulation, we are decidedly of the opinion that if a tarso-metatarsal disarticulation be impracticable, the marked advance in prosthetic appliances has made any operation short of a well-executed amputation at the lower third of the leg, archaic and obsolete.

Disarticulation at the Ankle Joint (Syme's Operation). (Figs. 162, 171, 173, 174.)—*Surgical Anatomy.*—The ankle joint is formed by the lower extremity of the tibia and its malleolus, the external malleolus of the fibula, and the astragalus. The articulating surfaces are covered with cartilage and enveloped by a capsular ligament. The latter structure is markedly thickened upon the inner aspect of the joint, where it forms the powerful deltoid ligament. The ligaments of the inner side of the ankle are shown in the accompanying cut (Fig. 172). The tendons about the ankle joint run in synovial sheaths and are arranged in the following manner: In front of

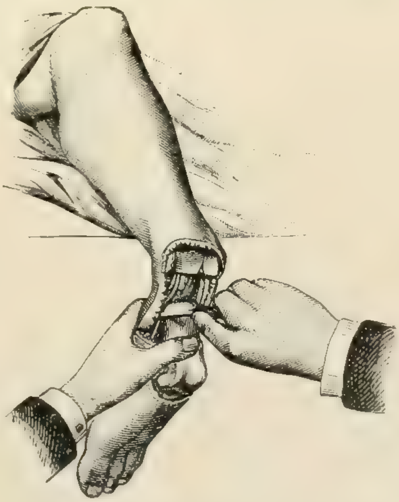


Fig. 170.—Decortication of the Posterior Extremity of the Os Calcis in Tibio-Tarsal Disarticulation. (Farabeuf.)

the joint, and from without inward, are the tendons of the extensor longus digitorum, the extensor proprius hallucis, and the tibialis anticus; at the inner side, and passing from the internal malleolus to the calcaneus, are the tendons of the tibialis posticus, the flexor longus digitorum, and the flexor proprius hallucis; at the outer side are the tendons of the peroneus longus and brevis. The posterior tibial artery divides into the internal plantar and the external plantar midway between the internal malleolus and the tuberosity of the calcaneus. The lower epiphysis of the tibia represents the articular surface as well as the internal malleolus; it unites with the shaft from the eighteenth to the nineteenth year. The lower epiphysis of the fibula is the external malleolus; it unites with the shaft during the twenty-first year. The posterior epiphysis of the calcaneus appears in the tenth year and joins the body of the bone at about the fifteenth year.

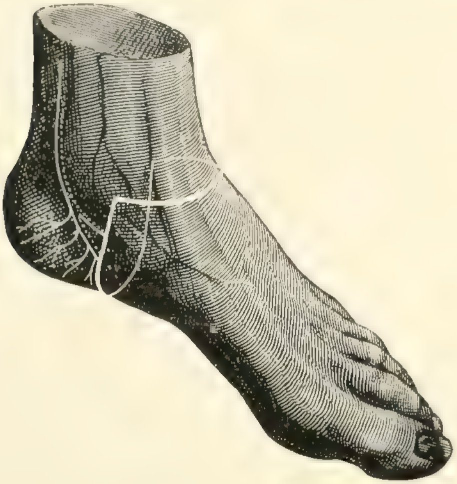


Fig. 171.—Lines of the Incisions employed in Syme's Amputation of the Foot. The other white and black lines show the relations of the plantar arteries to these incisions, and also the importance of the ramifications of these vessels, and especially of the external plantar artery, to the proper nourishment of the flap. (Farabeuf.)

The Operation. (Figs. 162, 171, 173, 174, and 175.)—The instruments required are: a stout knife, with a narrow blade three inches in length, a rounded point, and a large strong handle; a scalpel; a saw; bone forceps, retractors, dissecting forceps, hæmostats, scissors, and needles.

The patient should be in the dorsal position, with the foot well beyond the edge of the table and at the level of the surgeon's face. An assistant steadies the leg with one hand, and with the other he rigidly maintains the foot at a right angle to the leg. A second assistant looks after the wound. The surgeon sits facing the sole of the foot while fashioning the heel flap, and stands to cut the dorsal flap and disarticulate. The point of the knife is introduced at the tip of the external malleolus somewhat nearer the posterior than the anterior border, and the incision is carried di-

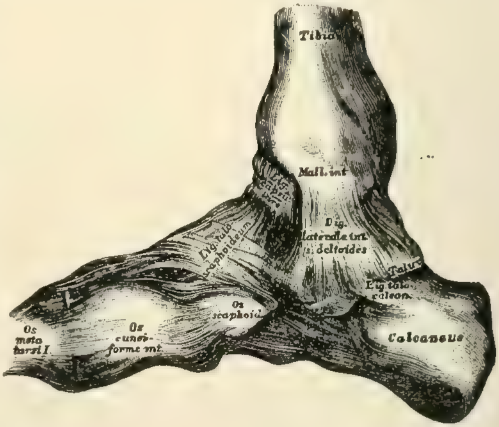


Fig. 172.—Internal Lateral Ligaments of the Ankle.

rectly downward at a right angle to the long axis of the foot. It traverses the sole and passes directly upward to terminate about half an inch below the tip of the internal malleolus. Under no circumstances should the inner extremity of the plantar incision pass *behind* the internal malleolus, since then it is apt to sever the posterior tibial artery and thus deprive the flap of its main blood supply which it gets from the internal calcanean artery.

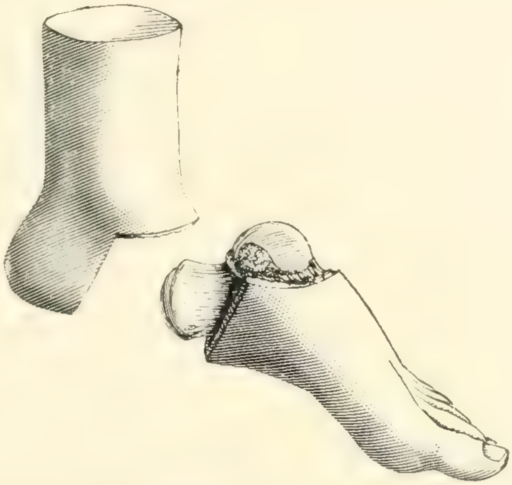


Fig. 173.—Tibio-Tarsal Disarticulation According to Syme's Method. Heel flap. (Farabeuf.)

It is much safer to shape the heel flap by two cuts starting respectively at the outer and inner extremities of the above-described incision and meeting at the sole. The heel flap is now dissected back and the calcaneus clearly exposed. It is of great importance to keep close to the bone, and the dissection is continued until the tuberosities and the posterior surface of the calcaneus are thoroughly laid bare. It is well to peel off the periosteum with the heel flap, and in subjects under fourteen the posterior epiphysis of the calcaneus is separated and allowed to remain in the stump. After this, the surgeon stands up and forcibly extends the foot with his left hand, while connecting the extremities of the plantar incision by a cut directly across the front of the ankle. This dorsal incision is carried down to the bone, and the extensor tendons are all divided when they are put upon the stretch.

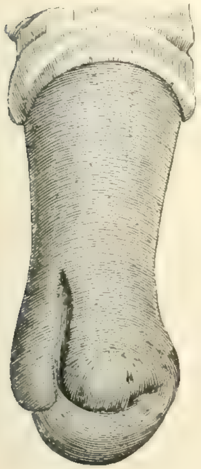


Fig. 174.—A Syme's Stump Soundly Healed after Scraping out of Sinuses had been Resorted to. The patient had active secondary syphilis as well as extensive caries of the tarsus. (From Jacobson and Steward: "Operations of Surgery.")

The ankle joint lies just above the dorsal incision and is opened by dividing the anterior ligament. The knife is passed into the joint, and the lateral ligaments are divided from within outward. The posterior ligament is next divided, the superior surface of the calcaneus exposed, and the disarticulation completed by dividing the tendo Achillis.

Both malleoli and the lower extremity of the tibia are now exposed by dissecting back the soft parts. The assistant retracts the flaps out of harm's way while the surgeon saws the bones horizontally, about a quarter of an inch above the lower margin of the tibia. This saw-cut should just remove the inferior articular surface of the tibia, and particular care should be taken, in young subjects, not to remove the entire lower epiphysis of the tibia.

The anterior tibial artery is secured in the centre of the dorsal flap, and the external and internal plantar arteries are secured at the inner extremity of the heel flap. The internal malleolar branch of the posterior tibial (behind the internal malleolus), the anterior peroneal artery (in front of the ankle joint), and the external and internal malleolar branches of the anterior tibial artery (in front of their respective malleoli) may also demand attention. A short drainage tube is introduced through an incision in the centre of the heel flap.

The stump after a properly executed Syme's amputation is strong and satisfactory. The patient should be provided with a special boot to overcome the shortening. A prosthetic appliance can be admirably adjusted to this stump.

Wyeth has pointed out that the chief blood supply of the heel flap is from the calcaneal branches of the external plantar artery, and he draws the conclusion that a longer plantar flap would be less likely to slough than a short one.

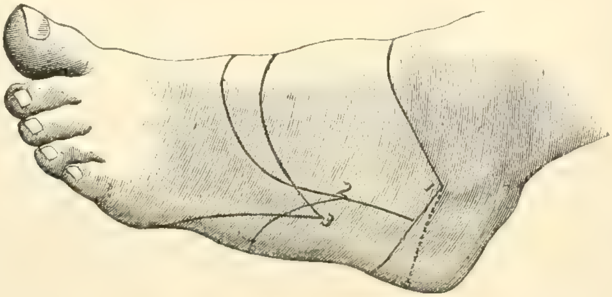


Fig. 175.—The Incisions Required in Different Amputations of the Foot. 1, The incisions in Pirogoff's amputation. The dotted line shows the direction of the plantar incision in Syme's amputation; 2, The incisions in subastragaloid amputation; 3, The incisions in Chopart's amputation. (From Jacobson and Steward: "Operations of Surgery.")

If such a long plantar flap be made, it should be raised from the calcaneus, from behind forward, after disarticulating and dividing the tendo Achillis.

Roux's Disarticulation at the Ankle Joint.—This is a modification of the oval method, the consensus of opinion seeming to be that it is distinctly inferior to Syme's operation.

Pirogoff's Operation. (Figs. 162, 175, 176.)—This is an osteoplastic intracalcaneal amputation. It differs from Syme's operation in that the calcaneus is sawn through, and the cut surface of the posterior segment is applied to the sawn surfaces of the tibia and fibula. The incision resembles that employed in Syme's operation, but the heel flap is a trifle longer and the dorsal cut more convex. The plantar incision commences just in advance of the external malleolus, and terminates at a point directly opposite, and slightly in front of, the internal malleolus. The heel flap is dissected backward for a distance of a quarter of an inch.

After the foot has been disarticulated it is forcibly drawn forward in a position of complete extension, exposing the entire upper surface of the calcaneus. (Fig. 176.) The saw is applied to this surface a finger's breadth behind the astragalus, and the plane of the bone section should correspond to that of the edges of the heel flap. During the bone section the heel flap should be kept out of harm's way by an assistant.

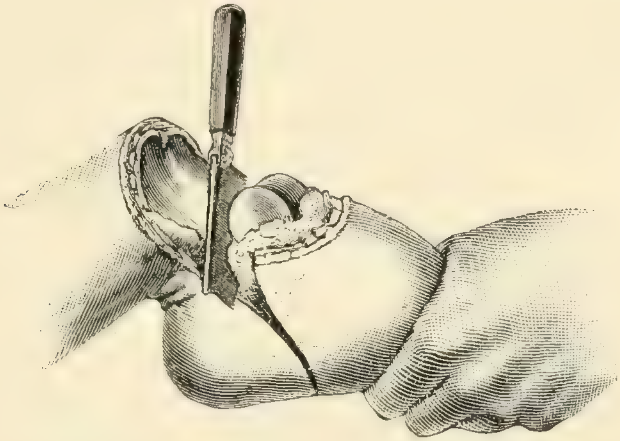


FIG. 176.—Division of the Os Calcis in Pirogoff's Amputation of the Foot. (From Jacobson and Steward: "Operations of Surgery.")

The lower ends of the tibia and fibula are now cleared as in Syme's amputation. The saw is applied to the anterior aspect of the bones immediately above the articular surface of the tibia, and the bones are sawn through somewhat obliquely, so that the saw emerges upon the posterior surface of the tibia about a finger's breadth above the articular surface.

The stump, after Pirogoff's amputation, is longer than that after a Syme's operation, but it possesses no other advantage over the latter procedure. The fragment of the calcaneus left behind may necrose and be drawn backward by the muscles of the calf. The tendo Achillis should be divided.

In Le Fort's modification of Pirogoff's amputation (Fig. 177) the incision is practically racquet-shaped, the handle of the racquet commencing upon the outer side of the foot at the insertion of the tendo Achillis. The essential feature of the modification is that the calcaneus is sawn horizontally at the junction of the upper and middle thirds. The saw is applied just below the sustentaculum tali, and the insertion of the tendo Achillis is preserved. The resulting stump is said to be superior to that of Pirogoff, since the entire length of the calca-

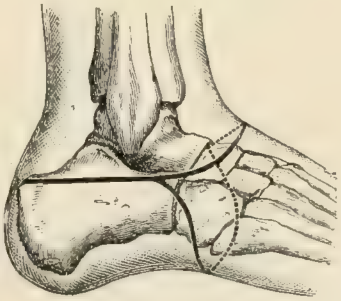


FIG. 177.—Pasquier and Le Fort's Operation. (From Treves' "Operative Surgery.")

neus rests upon the ground, and the skin covering it is already adapted to withstand direct pressure.

In Sédillot's and Gunther's modifications both the calcaneus and the bones of the leg are sawn obliquely.

In von Bruns' modification the sawn surface of the calcaneus is concave while that of the conjoined bones of the leg is convex.

The Wladimiroff-Mikulicz Osteoplastic Resection of the Foot.—This operation is of questionable utility and is rarely called for. The soft parts covering the heel are removed together with the calcaneus and astragalus, and the sawn surfaces of the tibia and fibula are brought in contact with those of the cuboid and navicular bones. In the majority of instances this operation has been done for tuberculous disease of the calcaneus and astragalus, and in these cases the reparative powers of the patient are rarely equal to the severe demands of the procedure. It may be employed in incurable ulcers of the heel or after gunshot injury, but it seems to be distinctly inferior to an amputation at the lower third of the leg. The patient must not only wear a specially constructed shoe upon the foot operated upon, but he must also be provided with a high sole upon the sound side.

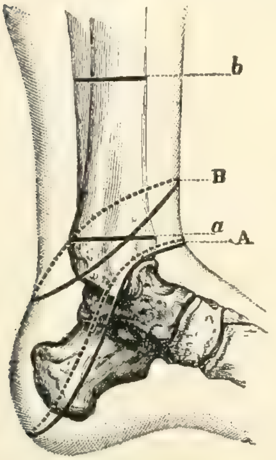


Fig. 178.—Amputations of the Lower Leg. (From Treves' "Operative Surgery.") *A*, Guyon's supramalleolar amputation (*a*, saw-line for that operation); *B*, Duval's supramalleolar amputation (*b*, saw line for that operation).

Hancock's Operation.—This is a combination of the subastragaloid and Pirogoff operations. The flaps are fashioned as in Pirogoff's amputation, but should be rather longer, and the calcaneus is similarly sawn. The astragalus is then sawn horizontally, and the sawn surface of the calcaneus is brought in contact with the similar surface of the upper portion of the astragalus. The head of the astragalus is also removed.

In the interest of the foot as a whole, Hancock also advocated dividing the tarsal bones in any situation, regardless of the location of the joints. The sole attention, he believed, should be paid to the complete removal of diseased or injured tissue.

Amputations in the Lower Third of the Leg.—With the advances which have been made in the manufacture of prosthetic appliances, this region of the limb is to-day the "place of election."

The instruments required are: a small amputating knife with a five-inch blade; a stout knife with a four-inch blade, having a narrow point and a strong handle; a scalpel, an amputating saw, an Esmarch's bandage, retractors, hæmostats, dissecting forceps, scissors, and needles.

Guyon's Supramalleolar Method. (Fig. 178.)—The oblique elliptical incision commences in the anterior median line at the level of the ankle joint and curves from above downward across the inner aspect of the ankle, just skirting the internal malleolus. After crossing the summit of the heel it passes across the outer aspect of the ankle a trifle in front of the external malleolus and terminates at the point of starting. The surgeon now sits facing the sole of the foot and dissects up the heel flap, which should contain all the tissues down to the bone except the tendons of the peronei. The latter muscles are divided above the ankle joint. Care should be exercised not to damage the vessels upon the inner side of the calcaneus. The tendo Achillis is next divided, and the tissues are cleared away from the posterior aspect of the bones of the leg until a point is reached about two inches above the tips of the malleoli. The surgeon now stands, extends the foot upon which he is operating, and carries the anterior incision down to the bone without opening the ankle joint. The tissues on the front of the leg are then dissected up, and the anterior aspect of the bones of the leg is bared to the previously mentioned level. While the flaps are retracted by an assistant, the bones of the leg are sawn transversely just above the malleoli.

The posterior tibial artery will be found upon the inner side of the heel flap, and the termination of the peroneal artery upon the outer side. The anterior tibial artery is near the anterior border of the tibia, and the anterior peroneal is in front of the external malleolus. The posterior tibial nerve should be dissected out of the flap and divided high up. Drainage should be provided by a small incision through the posterior portion of the flap.

The good features of the stump are these: the cicatrix is well out of the pressure area, and the medullary canals of the bones of the leg are not opened up.

Duval's Supramalleolar Amputation. (Fig. 178.)—In this method an oblique elliptical incision is also employed, but the bone is divided at a much higher level than in the preceding operation. The level of the bone section having been decided upon, the incision is so planned that the lower and posterior extremity of the ellipse shall be placed below this at a distance equal to one and a half times the antero-posterior diameter of the limb as measured at the level of the pro-

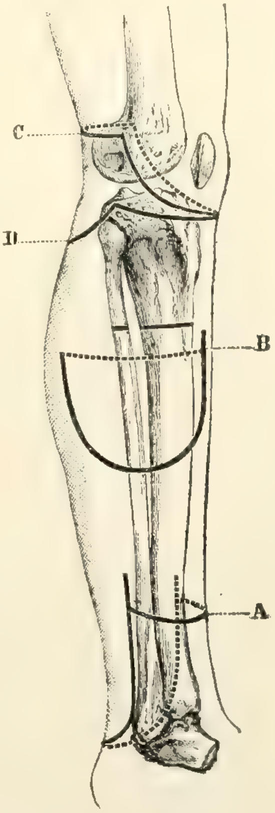


Fig. 179.—Amputations of the Leg. (From Treves' "Operative Surgery.") *A*, Amputation of lower part of the leg by a long posterior flap; *B*, amputation at the "place of election" by a large external flap (Farabeuf's operation); *C*, Carden's amputation; *D*, Lister's modification of the same.

posed bone section. The higher and anterior extremity of the ellipse should also be placed below this level, but at a distance not less than three-quarters of the antero-posterior diameter measured at the same level. The plane of the incision is inclined at an angle of forty-five degrees. The first incision simply divides the skin, which is allowed to retract. The soft parts are then divided down to the bone in the line of the retracted skin. The tendo Achillis is divided near its insertion, and the soft parts are cleared from the bones to a point just above the level of the section previously decided upon. While the tissues are being dissected up from the posterior aspect of the limb the surgeon should be seated with the leg elevated in front of him. After the bones have been sawed, the posterior tibial nerve should be dissected out from the posterior flap. The tendo Achillis may be retrenched or, as advised by some authorities, sutured to the cut end of the extensor muscles.

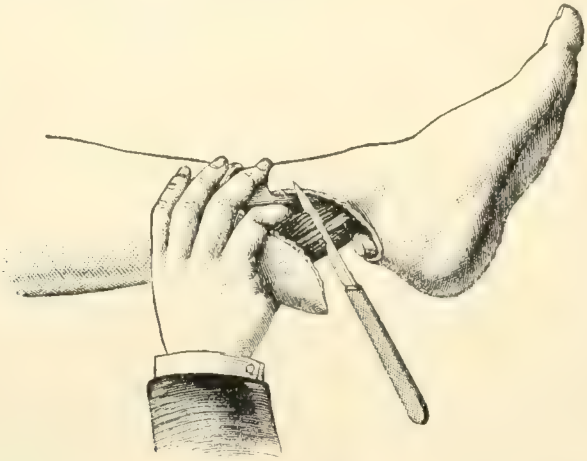


Fig. 180.—Mode of Dividing the Tissues in the Amputation by a Large Posterior Flap. (From Treves' "Operative Surgery.")

The anterior tibial artery is secured in front of the tibia, the posterior tibial behind this bone, the posterior peroneal behind the fibula, and the anterior peroneal in the posterior flap, opposite to the interosseous space. The wound was originally closed by uniting the elliptical incision transversely, the resulting cicatrix being situated upon the anterior aspect of the stump. Some surgeons suture the wound in an antero-posterior direction to secure better drainage, but this is disadvantageous, since the resulting scar is terminal.

Amputation by a Long Posterior Flap. (Figs. 179 and 180.)—The length of the posterior flap after retraction has taken place should be equal to half the circumference of the limb at the level of the bone section. The length of the anterior flap is about one-fourth that of the posterior. If the right leg be the subject for amputation the foot is everted, the knife entered at the level of the proposed bone section, and the incision carried downward in front of the internal border of the tibia and terminated by curving outward across the insertion of the tendo Achillis. The foot is now inverted and the external incision is made from above downward behind the fibula, where it meets the internal one at the insertion of the tendo Achillis. After the flap has retracted, the tendo Achillis is divided.

A deep incision, two inches in length, is now made in the line of the skin-cut upon both the inner and the outer aspects of the limb, and these incisions are carried down to the tibia and fibula respectively. The two wounds are deepened by blunt dissection and the muscles separated from the underlying bones and interosseous membrane. With the thumb in one wound and the index finger in the other, the surgeon now holds up the soft parts with his left hand, while he completes the posterior flap by cutting through the muscles from without inward, the foot being held in forced flexion by an assistant. The anterior flap is next fashioned by first dividing the integument, then the soft parts after the integument has retracted, and finally dissecting them away from the bones and interosseous membrane. After the latter structure has been incised, the flaps are retracted by an assistant, and the tibia and fibula divided by the saw. As in all amputations at this level, the posterior tibial nerve should be exposed and divided at a high level.

The anterior tibial artery is secured in the anterior flap in front of the interosseous space. The posterior tibial and the peroneal arteries will be found in the posterior flap, the former at the middle and the latter behind the fibula. The muscles upon the anterior and posterior aspects of the leg may be united by catgut sutures. The stump is usually a most serviceable one, and the transverse cicatrix is well away from the pressure area.

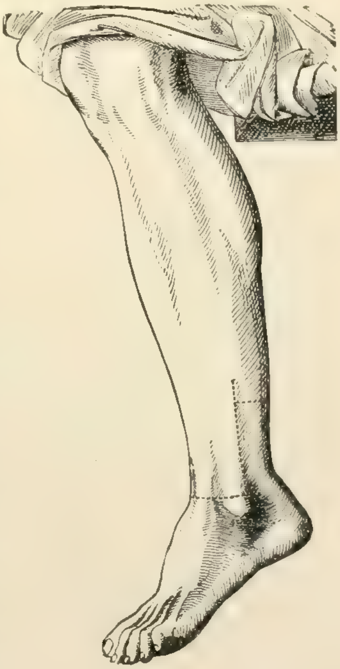


Fig. 181.—Teale's Amputation of the Leg by Rectangular Flaps. The dotted line indicates where the incision is to be made. (From Jacobson and Steward: "Operations of Surgery.")

Teale's Amputation with a Large Anterior Flap. (Figs. 181–184.)—This method may be employed in exceptional cases where the tissues have been disintegrated high up upon the posterior aspect of the leg, but in ordinary cases it necessitates too great sacrifice of bone. The length and breadth of the anterior flap should equal one-half the circumference of the limb at the proposed saw-cut. The posterior flap should be one-fourth the length of the anterior one. Particular care should be taken to make the anterior flap just as broad below as it is above. If Teale's amputation has any place in surgery, this is the most favorable site for its performance.

THE MODIFIED CIRCULAR AMPUTATION.—The chief objection to this method always has been that it leaves a terminal scar. At the present day this objection is no longer valid, since the modern artificial limb does not press against the end of the stump at all, but supports the patient by making pressure upon the sloping sides of the extremity. In view of this fact the writers regard this method as the normal procedure in the lower third. (Fig. 185.)

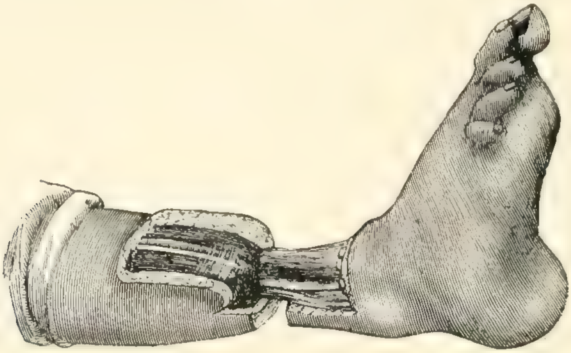


FIG. 182.—Teale's Amputation of the Leg. The incision in the skin has been completed and the flap has been turned back. (From Jacobson and Steward: "Operations of Surgery.")

Two lateral semilunar flaps are fashioned, the length of which is equal to rather more than one-quarter of the circumference of the limb at the level of the proposed saw-cut. The bases of the flaps are situated at this level and are of equal width. After the skin flaps have been raised, the soft tissues are divided circularly and the interosseous membrane is cleanly incised. A three-tailed retractor is now applied and the bones are sawn across, the fibula being divided about half an inch higher than the tibia. Periosteal flaps may be raised with the soft parts and are of value.

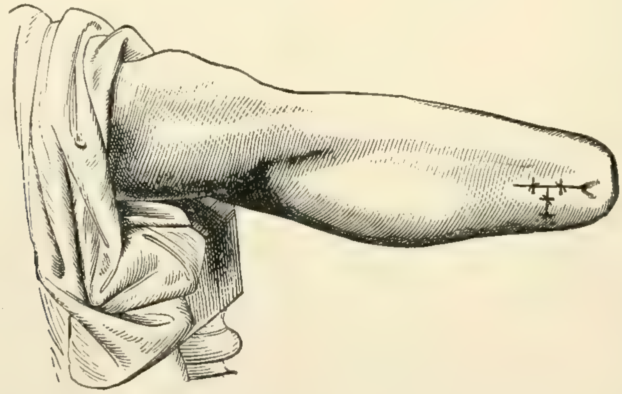


FIG. 183.—Teale's Amputation of the Leg Completed. (From Jacobson and Steward: "Operations of Surgery.")

The anterior tibial artery is secured in front of the tibia between the extensor digitorum longus and the extensor hallucis longus. The posterior tibial artery is behind the inner border of the tibia at the outer margin of the flexor digitorum longus. The peroneal artery hugs the inner border of the fibula in the substance of the flexor hallucis longus. The anterior and posterior tibial nerves are cleanly divided at the highest possible level, and the wound is united anteroposteriorly by sutures. A small drainage tube should be inserted at either angle and retained for twenty-four hours.

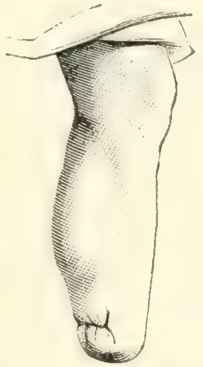


FIG. 184.—Transverse Posterior Cicatrix in the Stump left by a Teale's Amputation of the Lower Half of the Leg. (Farabeuf.)

Amputations in the Middle Third of the Leg.—The instruments required are an amputating knife with a five-inch blade, a strong scalpel, an amputating saw, an Esmarch's bandage, a three-tailed retractor, a periosteal elevator, hæmostats, dissecting forceps, scissors, and needles.

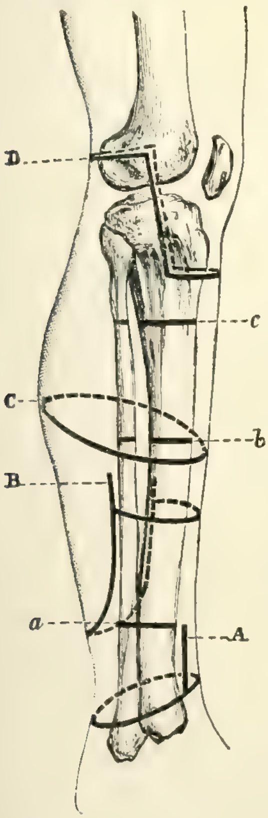


FIG. 185.—*A*, Modified Circular Supramalleolar Amputation (*a*, saw-line of same); *B*, Hey's amputation (*b*, saw-line of same); *C*, circular amputation at "the place of election" (*c*, saw-line of same); *D*, Gritti's operation. (From Treves' "Operative Surgery.")

AMPUTATION BY A LARGE POSTERIOR FLAP (HEY'S OPERATION). (Fig. 185.)—The surgeon stands to the outer side of the right leg or the inner side of the left, as the case may be. The patient's knee should be beyond the edge of the table. Having decided upon the level of the bone section, the surgeon should measure the circumference of the leg at this point and should so fashion the posterior flap that its length and breadth shall be equal to one-half of this measurement. The anterior flap should be one-third the length of the posterior one. If the amputation be upon the right side, the limb is rotated outward, the knee flexed, and the knife introduced about one inch below the proposed bone section and just behind the inner border of the tibia. The incision is carried vertically downward behind this border and terminated by curving outward to form one side of the U-shaped flap. The leg is now rotated inward and the external limb of the U made by cutting from above downward just behind the peronei. The posterior cutaneous incision is carried well through the integument, which is allowed to retract freely. The knee is now flexed and turned outward and the gastrocnemius divided transversely in the line of the end of the flap. Two deep vertical incisions are next made in the line of the edges of the flap, the inner one extending to the tibia, and the outer to the fibula behind the peronei. These incisions are then deepened by blunt dissection until the thumb and forefinger can be brought in contact between the deep musculature and the bone, when the posterior flap is finished, as in the posterior-flap operation in the lower third. The soft parts are then carefully raised from the bones until the level of the proposed bone section is reached.

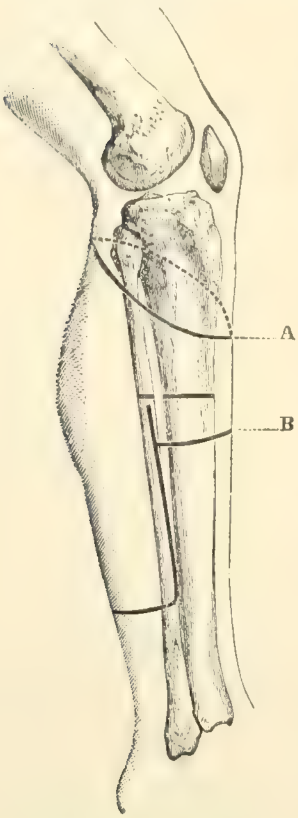


FIG. 186.—*A*, Disarticulation at the Knee by the Elliptical Method (Bauden's operation); *B*, Henry Lee's amputation of the leg. (From Treves' "Operative Surgery.")

The anterior incision is next made through the skin, which is allowed to retract. The muscles are then divided down to the bones at the edges of the retracted flap, and the anterior flap is dissected upward until the site of the future saw-cut is exposed. The interosseous membrane having been carefully divided, a three-tailed retractor is applied and the bones are sawn. The fibula should be divided half an inch higher than the tibia, and the sharp crest of the latter bone should be removed either by the rongeur alone or by this instrument after a preliminary oblique cut has been made with the saw.

The anterior tibial artery is secured in the anterior flap opposite the interosseous space. The posterior tibial and peroneal arteries are situated in the posterior flap, the former between the tibialis posticus and the flexor longus digitorum, and the latter in the substance of the flexor proprius hallucis. The posterior tibial nerve should be dissected out of the posterior flap and divided as high up as possible.

The stump resulting from this operation is a serviceable one and the cicatrix is placed anteriorly well out of the pressure area.

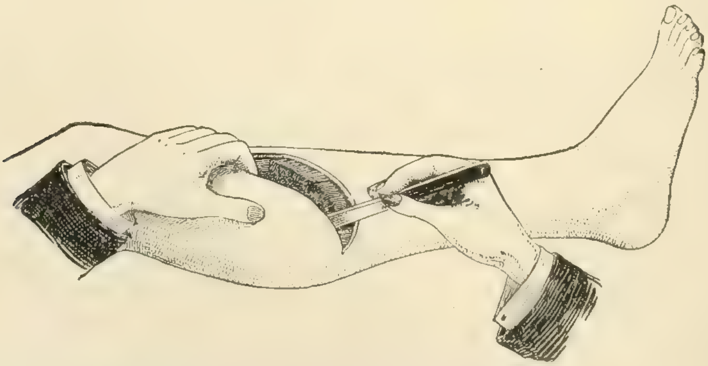


FIG. 187.—Mode of Cutting the Flap in the Amputation at the "Place of Election" (see *B*, Fig. 185) by a Large External Flap. (After Farabeuf, from Treves' "Operative Surgery.")

Lee's Amputation by a Large Posterior Flap. (Fig. 186.)—This operation is identical with Teale's method, except that the posterior flap is the longer and includes only the superficial muscles of the calf. It is easier of execution than Hey's amputation in this situation, but requires a higher division of the bones.

Amputation by a Long External Flap.—The width of the external flap should equal one-half of the circumference of the leg at the site of proposed section of the bones, and its length should be equal to one-third of this measurement. It may contain either skin alone or both skin and muscle. The internal flap is short and semilunar in shape. The bones are divided just above the angle of the junction of the two flaps, and the edges of the bones should be bevelled either with the saw or with the rongeur forceps.

The resulting stump is serviceable and the scar well placed upon the inner side.

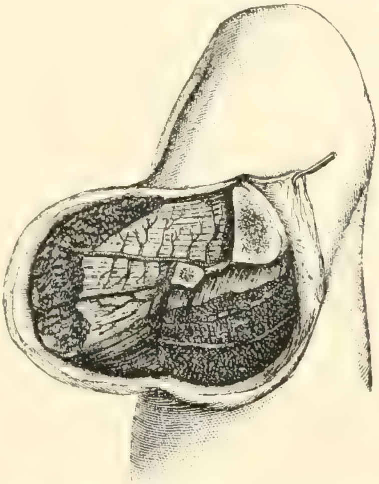


Fig. 188.—Appearance of the Stump after the Amputation of the Leg at the "Place of Election" by a Large External Flap. (After Farabeuf, from Treves' "Operative Surgery.")

The Modified Circular Method.—For the reasons previously stated, the writers prefer this method here, as in the lower third of the leg. (Page 338.) It is carried out in an analogous manner.

Amputation in the Upper Third of the Leg.—The usual amputation in this region is done at the so-called "place of election," *i.e.*, the bones are divided a hand's breadth below the knee joint. The instruments required are: an amputating knife with a six-inch blade, a strong scalpel, an amputating saw,

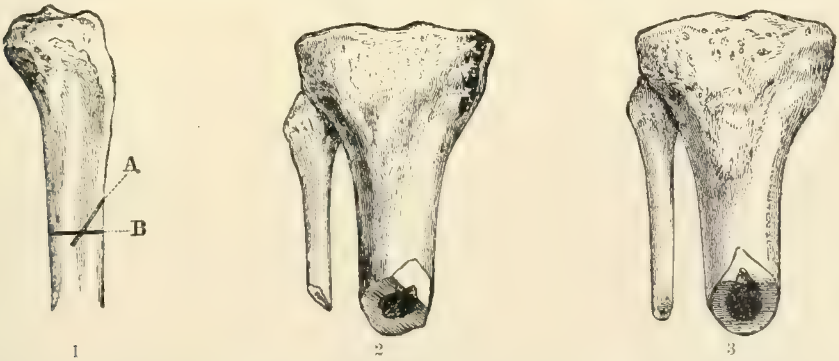


Fig. 189.—Methods of Sawing the Bones of the Leg. (From Treves' "Operative Surgery.") 1, Method of sawing the tibia, the saw being directed at first downward and outward, in the direction of the line *A*, and afterward transversely from before backward, in the direction of the line *B*. In 2 and 3, the final results are shown; in the latter figure the sawing of both the tibia and the fibula has been slightly different from that shown in 2.

a periosteal elevator, an Esmarch's bandage, retractors, dissecting forceps, haemostats, scissors, and needles.

Amputation by a Large External Flap. (Figs. 187–190.)—This method, originally devised by Sédillot and greatly elaborated by Farabeuf, has long been popular. In operating upon the right leg the surgeon stands upon the outer side of the limb throughout the amputation; upon the left leg, he takes up his position at the foot and slightly to the outer side while outlining the flap, but stands at the inner side during the subsequent steps. The length of the external U-shaped flap should be one-third the circumference of the limb at the level of the proposed bone section.

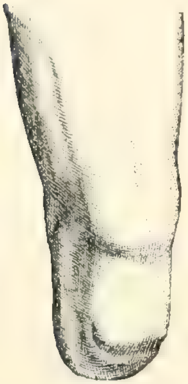


Fig. 190.—Stump Resulting from Amputation of the Leg at the "Place of Election" by a Large External Flap. (After Farabeuf, from Treves' "Operative Surgery.")

The knee having been flexed and the leg turned so that its outer aspect is well exposed, the knife is introduced at the level of the future saw-cut and the anterior limb of the U is made by carrying the incision downward parallel with, and to the inner side of, the crest of the tibia. The posterior limb of the U is placed upon the back of the calf exactly opposite the anterior one, but it terminates about an inch and a half below the level of the proposed saw-cut. The leg is now turned upon its outer side and an incision is carried transversely from the upper extremity of the posterior limb of the U to the anterior limb, which it should join about an inch and a half below the commencement of the latter.

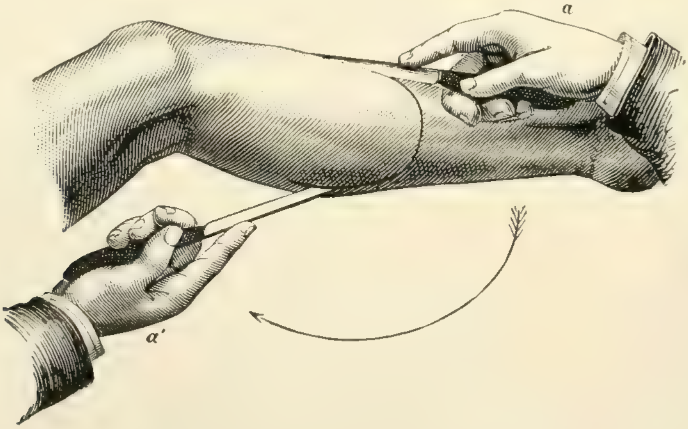


Fig. 191.—Amputation of the Leg by (modified circular) Lateral Flaps. (After Farabeuf, from Jacobson and Steward: "Operations of Surgery.") *a*, Position of the knife in the hand of the surgeon at the beginning of the incision; *a'*, its position when the incision is completed.

The leg having again been rotated inward, the external flap is dissected up, the dissection commencing at the anterior limb of the U. The soft parts should all be in the flap, but they are divided obliquely below so as to render this edge of the flap much thinner. Great care should be exercised not to carry the dissection too high, since the anterior tibial artery might inadvertently be divided at the point where it pierces the interosseous membrane. The nutrition of the flap is derived almost entirely from this vessel.

The small internal flap is next raised and the bones are cleared; then a three-tailed retractor is applied, and the bones are divided. The fibula should be sawn across half an inch higher than the tibia, and it has been advised to bevel both bones laterally. The periosteum may be previously stripped up with the soft parts to form flaps which are subsequently applied to the ends of the divided bones.

The anterior tibial artery is secured at the margin of the external flap, while the posterior tibial and peroneal vessels will be found at about the same depth in the tissues of the internal flap. The resulting stump is most useful, the scar being situated upon the inner side and well out of the pressure area. The movements of the knee are retained.

Amputation by the Modified Circular Method. (Figs. 191 and 192.)—While the circular method may be employed in the upper third of the leg, the modified circular method will be found more satisfactory. Two equal lateral tegumentary flaps are dissected up and the soft parts are divided transversely. The bones are sawn in the customary manner.

The lengths of both flaps should slightly exceed one-quarter of the circumference of the leg at the site of the proposed bone section. The bases of the flaps should be three-quarters of an inch above the future saw-cut. The two semilunar incisions commence anteriorly, just to the outer side of the tibial crest, and meet posteriorly at a point diametrically opposite.

The stump is a serviceable one and, although the scar is terminal, the writers prefer this method here as in other regions of the leg.

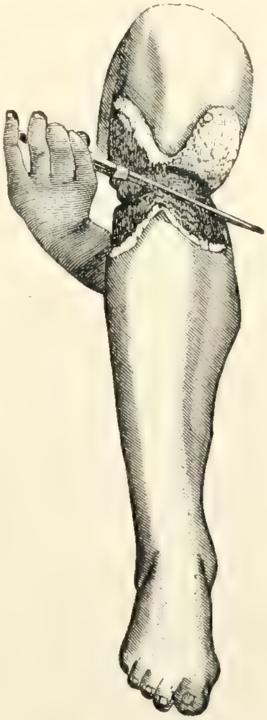


Fig. 192.—Amputation of the Leg by (modified circular) Lateral Flaps. The muscles are being severed with circular sweeps of the knife. (From Jacobson and Steward: "Operations of Surgery.")

Amputation at the Knee Joint.—Surgical Anatomy.—The knee joint is formed by the condyles of the femur, the tuberosities of the tibia, and the patella. The interarticular line is somewhat below the crease that passes transversely across the popliteal space, and at about the level of the lower border of the patella when the joint is extended. The internal condyle is more prominent than the external—an important point to remember in shaping lateral flaps. The external semilunar cartilage is smaller and more movable than the internal one. The tubercle of the tibia and the head of the fibula are situated in the same horizontal plane. The synovial membrane extends upward above the patella for about two inches. The skin over the front of the joint is dense, freely movable, and well nourished. The sites of the articular branches should be noted in order that the main vessel shall be not ligatured too near them, for apparent reasons. Care should also be taken to prevent the collection of fluid of any kind in the upper synovial pouch. Pressure and drainage are the expedients available under these circumstances.

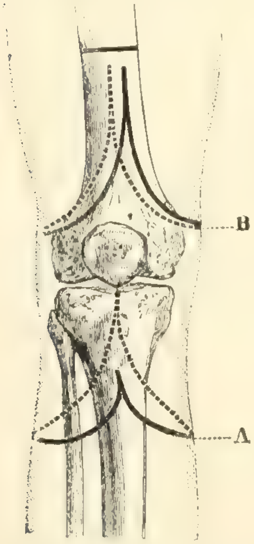


FIG. 193.—Amputations at the Knee Joint. (From Treves' "Operative Surgery.") *A*, Stephen Smith's disarticulation at the knee; *B*, amputation of the thigh by lateral flaps.

DISARTICULATION BY LATERAL FLAPS (STEPHEN SMITH). (Figs. 193, 194, and 195.)—The flap consists of skin only, the posterior muscles being divided transversely at the level of the interarticular line. The instruments required are: an amputating knife with a six-inch blade, a strong scalpel, hæmostats, an Esmarch's bandage, dissecting forceps, retractors, scissors, and needles.

The patient should be in the dorsal position with the middle of the thigh at the lower margin of the table. The operator stands at the outer side of the right leg or at the inner side of the left. The knee is extended, the knife introduced anteriorly in the median line one inch below the tubercle of the tibia, and the incision carried in a sweeping curve outward across the most prominent portion of the calf. After reaching the middle line posteriorly it passes vertically upward to terminate at the level of the interarticular line. The inner flap is fashioned in a similar manner, but should be somewhat longer to provide sufficient covering for the prominent internal condyle. The two flaps are dissected up to the level of the joint, the ligamentum patellæ having been divided against the tuberosity of the tibia.

A transverse incision is next made along the upper margin of the tibia; it divides the ilio-tibial band, the tendons of the biceps, sartorius, gracilis, and semitendinosus, the internal and external lateral ligaments, and the coronary ligaments. In dividing the latter structures the surgeon should introduce the knife from the side of the articulation. After the knee has been flexed, the crucial ligaments are carefully severed. The flaps having now been retracted by an assistant, the disarticulation is completed by a transverse cut that divides the posterior ligament, the popliteal vessels

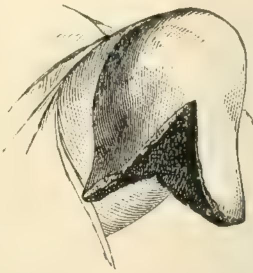


FIG. 194.—Stump after Amputation by Lateral Flaps, and Before the Sutures have been Applied. (After Stephen Smith.)

and nerves, the popliteus and gastrocnemius muscles, and the tendon of the semimembranosus.

The popliteal artery and vein are secured just behind the condyle. Other vessels which may demand attention are the sural arteries, the superior and azygos articular arteries, and the superficial branch of the anastomotica magna (in the internal flap). The semilunar cartilages should not be removed, since they prevent retraction of the soft parts and obviate any undue protrusion of the condyles.

This is undoubtedly the most satisfactory method of disarticulating in this location. The wound furnishes excellent drainage, and the stump is most serviceable, because of its broad bearing and the location of the cicatrix in the intercondyloid notch.

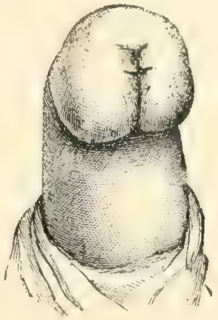


FIG. 195.—The Stump after Stephen Smith's Amputation at the Knee Joint. (After Bryant, from Treves' "Operative Surgery.")

DISARTICULATION BY THE ELLIPTICAL METHOD (BAUDEN'S OPERATION). (Fig. 186.)—The instruments required and the position of the patient and surgeon are the same as in the preceding operation. Having determined the antero-posterior diameter at the level of the interarticular line the surgeon should make the elliptical incision in such a manner that its lower and anterior portion shall cross the tibial crest at a distance below the interarticular line equal to the previously measured diameter. The higher and posterior portion of the ellipse crosses the posterior median line a half diameter below the same level. The skin upon the anterior aspect of the knee is now dissected up as far as the patella, and that upon the posterior surface is retracted to the interarticular line. The knee having been flexed, the ligamentum patellæ is divided, the knife is inserted between the semilunar cartilages and the head of the tibia, and the disarticulation is completed. No attempt should be made to dissect the patella from the anterior flap since this procedure greatly endangers the future welfare of the integument. The semilunar cartilages are also retained, for the reason given in the preceding description.

The resulting stump is a serviceable one, the cicatrix being upon the posterior aspect and well out of the pressure area.

DISARTICULATION BY A LONG ANTERIOR FLAP (POLLOCK'S OPERATION).—This method is not nearly so satisfactory as the two preceding ones. The condyles are not so well covered and the anterior flap is so long that it is very apt to slough.

AMPUTATION OF THE THIGH IMMEDIATELY ABOVE THE KNEE JOINT (CARDEN'S OPERATION). (Fig. 179.)—The instruments required are: an amputating knife with a six-inch blade, a strong scalpel, Butcher's saw, an Esmarch's bandage, retractors, hæmostats, dissecting forceps, lion-jaw forceps, scissors, and needles.

The patient and the operator should be in the same relative positions as in disarticulation at the knee joint. The knee is slightly flexed and the thumb and forefinger of the left hand are placed upon the most prominent part of each condyle. The anterior incision traverses the integument between these points in a gentle curve the convexity of which crosses the anterior median line about two inches below the patella. The posterior incision is practically transverse. The limb is now extended and the anterior flap dissected up; it should contain the capsular ligament and all of the soft tissues down to the patella. After the anterior flap has been liberated the tissues upon the posterior aspect of the thigh may be retracted above the level of the proposed saw-cut. The knee is flexed, the joint is opened above the patella through the quadriceps tendon, and the leg is disarticulated. With the soft parts well retracted the condyles are sawn across, the saw being held parallel to the articular surface and perpendicular to the femur. In patients under eighteen the saw should be applied below the level of the adductor tubercle so that the epiphyseal line shall not be disturbed.

The popliteal artery will be found close to the inner side of the bone. The popliteal vein is behind and to the outer side of the artery. The two superior articular arteries are divided close to the bone. The anastomotica magna is upon the inner side, and the descending branches of this artery and the branches of the descending portion of the external circumflex are located in the margin of the anterior flap.

LISTER'S MODIFICATION OF CARDEN'S OPERATION. (Fig. 179.)—This consists of making an anterior flap by a transverse incision across the front of the leg at the level of the tubercle of the tibia. There is also made a short posterior flap the edges of which are at an angle of forty-five degrees to the long axis of the leg. The posterior flap is dissected up, the hamstrings are divided, and the tissues upon the anterior aspect are raised until the upper border of the patella is exposed. The insertion of the quadriceps tendon is next divided and the bone is cleared immediately above the articular cartilage. The limb is finally removed by sawing through the femur, the saw being applied vertically and at right angles to the axis of the limb.

FARABEUF'S MODIFICATION OF CARDEN'S OPERATION.—This is almost a new procedure, although the bone is divided at the same level. An anterior U-shaped flap is fashioned, the length of which exceeds the antero-posterior diameter of the limb at the future saw line by about an inch. The base of this flap is just below the joint line; the outer edge is over the fibula, and the inner one is about two inches behind the internal margin of the tibia. A posterior flap, one-half the length of the anterior one, is next cut. The remaining steps of the operation are identical with those of Carden's amputation.

Either of these modifications gives a better stump than Carden's method, the cicatrix being well placed upon the posterior aspect of the limb.

GRITTI'S TRANSCONDYLOID AMPUTATION. (Fig. 185.)—In this operation the cartilaginous surface of the patella is removed, and the remainder of the bone is brought in contact with a section of the femur made at about the level of the adductor tubercle. It holds the same relation to Carden's operation as does a Pirogoff to a Syme's.

An anterior rectangular flap is fashioned, the base of which extends between the most prominent portions of the condyles, while its end reaches to the tibial tubercle. The skin upon the posterior aspect of the limb is divided by a transverse or slightly curved incision which connects the ends of the anterior one. The ligamentum patellæ is divided at its insertion and the anterior flap is dissected up. The section of the condyles is made in the usual manner. The assistant now holds the anterior flap with both hands in such a manner that the patella projects, and a second assistant steadies it with a lion-jaw forceps while the first saw-cuts are made. During the sawing the surgeon aids in the fixation of the patella by holding the ligamentum patellæ in a strong pair of forceps in the left hand. A much safer way of removing the articular surface of the patella is by means of the rongeur forceps.

There are many objections to this operation. There is quite a difference in the areas of the apposed bone sections, and it is almost impossible to keep the patella in close contact with the sawn surface of the femur, owing to the facts that the latter bone is divided so low and that the quadriceps pulls the patella upward. Sabanajew sought to overcome these objections by forming a bone flap from the upper and anterior aspect of the tibia, including the insertion of the patellar ligament, and bringing this flap in contact with the sawn surface of the condyles. A much better operation is the one which we shall next describe.

STOKES' SUPRACONDYLOID AMPUTATION.—In this operation the femur is sawn from half to three-quarters of an inch above the condyles. This sawn surface corresponds more accurately with that of the patella than does the bone section in Gritti's method. The medullary canal is not opened up by the saw. Owing to the higher division of the femur the quadriceps is relaxed and shows but little tendency to pull the patella upward.

An anterior oval flap is made by incisions which start from two points, situated one inch above each condyle, and which extend to just below the tibial tubercle. A posterior flap, one-third of the length of the anterior one, is also fashioned by cutting from without inward.

In concluding the operation the surgeon may suture the soft parts above the patella to the posterior flap, and he may cause the bones to be held together by the employment of catgut sutures.

Amputation of the Thigh.—There are several methods of performing an amputation of the thigh. We shall describe here briefly some of the more important ones.

THE CIRCULAR AMPUTATION. (Figs. 196 and 197.)—The instruments required are an amputating knife with an eight-inch blade for the circular method, an amputating knife with a ten-inch blade if transfixion is to be employed, a stout scalpel with a four-inch blade, an Esmarch's bandage, a large amputating saw, a small Butcher's saw, hæmostats, dissecting forceps, retractors, scissors, and needles.

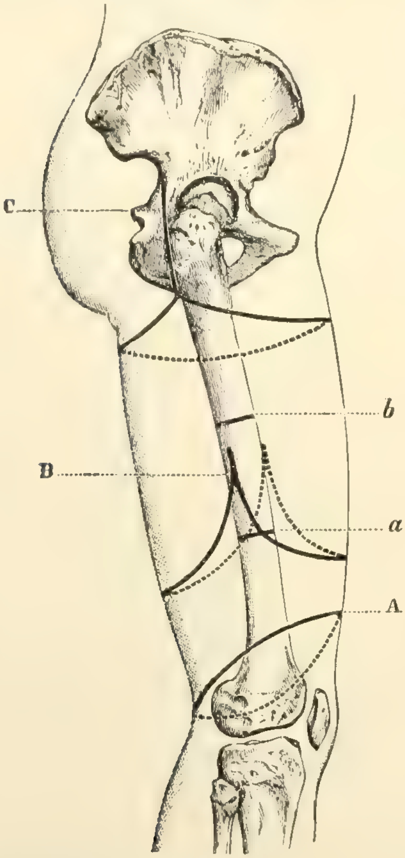


FIG. 196.—*A*, Circular Amputation of the Thigh (*a*, saw-line of same); *B*, amputation of thigh by equal antero-posterior flaps (*b*, saw-line of same); *C*, disarticulation at the hip by an external racquet incision. (From Treves' "Operative Surgery.")

This method is applicable only to the lower third, and, owing to the greater retraction of the muscles upon the posterior and inner aspect of the thigh, the incision must be obliquely placed. Upon the posterior and inner aspect of this part of the limb the distance between the cutaneous incision and the site of the proposed division of the bone should be equal to about one-third of the circumference of the thigh at the latter level. The similar distance upon the anterior and external aspect of the thigh should be equal to one-fourth of the same circumference. When the skin is retracted great care should be exercised to preserve the original obliquity of the incision. No attempt should be made to turn back a "cuff," as such a procedure is usually impossible and always endangers the future nutrition of the integument. After the skin has been well retracted the postero-inferior muscle groups are severed by a vigorous sweep of the knife and allowed to retract. The remaining muscles are now divided at the level of the retracted ones, the plane of division being oblique, to correspond with the cutaneous incision. After the bone has been cleared, a two-tailed retractor is applied and the femur divided with the saw. The projecting linea aspera should be carefully rounded off with a rongeur forceps. Some operators consider it wiser to sever the muscles singly, especially the posterior group, thus permitting each to retract in accordance with its individual characteristics.

The femoral (or the popliteal) artery and the descending branch of the external circumflex artery are ligated, together with any other branches that may demand attention.

This and the following method are the ones to be adopted when there is not sufficient tissue to form a long anterior flap, the chief advantages being the comparatively small size of the wound, the smallest possible section of the muscles, and the clean division of the main vessels.

Syme's Modification of the Circular Amputation.—In this procedure two lateral vertical releasing incisions are made which greatly aid in the elevation of the skin. The flaps, for a distance of two inches above their bases, are dissected up, the exposed muscles are divided in front at their highest and behind at their lowest level, a two-tailed retractor is applied, and the bone is sawn two inches above the level of the division of the anterior muscles. This is the method we have usually selected whenever it could be employed.

The Amputation by Equal Lateral Flaps. (Vermale.)—The length of each U-shaped flap should be equal to the diameter of the limb at the level of the bone section. The flaps are both cut by transfixion, the knife being inserted just below the level of the proposed saw-cut. Both flaps are forcibly retracted and an incision is made around the femur at least an inch higher than the site of transfixion. The chief objections to this method are those inseparable from transfixion, viz., the tendency to unequal retraction of the flaps and to forward projection of the femur.

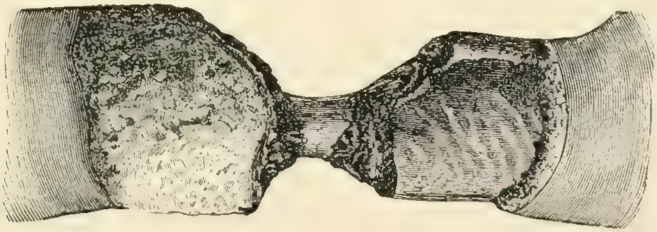


Fig. 197.—Circular Amputation of the Thigh. To show the greater retraction of the muscles behind. (From Jacobson and Steward: "Operations of Surgery.")

The Amputation by Equal Antero-Posterior Flaps. (Fig. 196.)—The base of each U-shaped flap is equal to one-half the circumference of the limb. The posterior flap should be cut somewhat longer than the anterior one, to allow for retraction. The general rule is to make the posterior flap equal in length to the diameter of the thigh at the level of the proposed bone section, while the length of the anterior flap should be about three-fourths of this diameter. If this method be employed the flap should be cut from without inward, and not by transfixion, as was formerly the practice.

Amputation by the Long Anterior and Short Posterior Flaps. (Farabeuf.) (Fig. 198.)—Both flaps are U-shaped. The base of the anterior flap exceeds one-half the circumference of the thigh, and its length should be equal to one and one-half diameters of the extremity at the level of the proposed bone section. The length of the posterior flap is equal to one-half of the same diameter. In cutting these flaps the surgeon should carry the first incisions through the integument alone. The soft parts in the anterior flap are then held in the left hand and the contained muscles are divided obliquely from without inward until the bone is exposed. The posterior flap is fashioned in a similar manner, although, if the thigh be very muscular, transfixion may be employed. Both flaps are thinnest at their extremities, but their bases include all of the muscles down to the bone. A two-tailed retractor is applied and the bone divided in the usual manner. If the amputation be performed above the middle of the thigh the femoral and the profunda arteries will both be found in the anterior flap. If the amputation be made below the middle of the thigh the anterior flap should be placed slightly toward the outer side, to avoid splitting the femoral artery. When the amputation is exactly in the middle of the thigh and the anterior flap is antero-external, the femoral artery is divided in the posterior flap. The descending branch of the external circumflex is always found in the anterior flap. In the lower third of the thigh the anastomotica magna will be found at the inner side of the posterior flap.

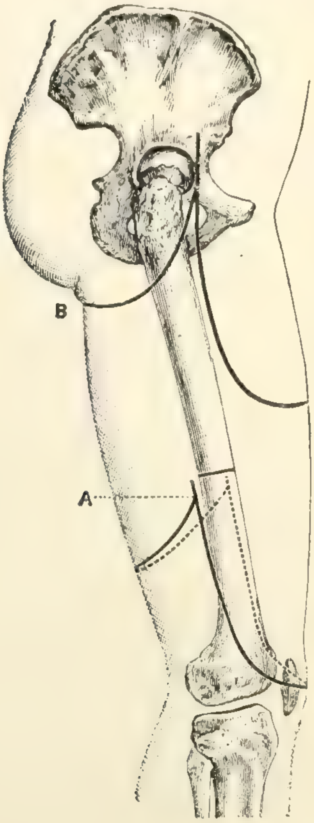


FIG. 198.—*A*, Amputation of the Thigh by Long Anterior and Short Posterior Flaps; *B*, Disarticulation at the hip by antero-posterior flaps. (From Treves' "Operative Surgery.")

Disarticulation at the Hip Joint.—SURGICAL ANATOMY.—The hip joint is formed by the acetabulum and the head of the femur. The thickest portion of the capsular ligament is in front and is known as the ilio-femoral ligament. The following muscles are in relation with the joint: anteriorly, the psoas and iliacus; superiorly, the reflected head of the rectus and the gluteus minimus; internally, the obturator externus and the pectineus; posteriorly, the pyriformis, the obturator internus with the gemelli, the obturator externus, and the quadratus femoris.

The largest bursæ about the joint are those behind the trochanter and the gluteus maximus, and between the latter muscle and the vastus externus. The pubic spine and the great trochanter are at about the same level, and the tip of the latter is opposite to the centre of the hip joint. The gluteo-femoral crease does not correspond with the lower margin of the gluteus maximus, but is situated at a higher level.

The common femoral artery lies upon the psoas, which separates it from the capsular ligament of the hip joint. The profunda femoris arises an inch and a half below Poupart's ligament, while the two circumflex arteries arise half an inch below. The internal circumflex artery passes backward to the level of the lesser trochanter.

It is of the greatest importance to guard, so far as is possible, against shock. This is to be done by having the temperature of the operating-room raised, and the trunk and limbs swathed in wool or cotton. A hypodermatic injection of morphia and atropine should be given one hour preceding the operation. Everything should be in readiness for enteroclysis and hypodermoclysis—the former to be used in every case, the latter to supplement it if shock be profound. (See article on Surgical Shock, in Vol. I.)

Particularly must every precautionary measure be taken if the operation is made necessary by traumatism, for in such cases the mortality is excessive, and the shock of the operation, added to that already existing from the injury received, will generally cause this to be the most fatal operation in surgery. In operations for the cure of disease the conditions are quite different.

Methods of Controlling Hemorrhage.—Many tourniquets have been devised for making pressure upon the abdominal aorta. In the absence of a special instrument a firm pad, such as a pin-cushion, has been placed over the aorta at the level of the iliac crest and held in position by elastic bands which do not encircle the waist, but are connected with the ends of a rigid object placed transversely beneath the back and extending laterally beyond the body. Such methods, however, are dangerous, since they may cut off some of the circulation of the intestine, cause gangrene of the tissues, and produce sudden engorgement of the viscera. They also may fail to accomplish the desired purpose by reason of the fact that the compressing appliance is easily disturbed and consequently fails to arrest the circulation in the lower aorta. One grave objection is that they do not control venous bleeding at all. If pressure is to be made upon the aorta, Macewen's method may be employed. In this method an assistant places his right fist slightly to the left of the umbilicus and makes the necessary pressure.

A valuable and accurate method of compression is that suggested by McBurney, who makes his "gridiron" incision for appendicitis and then has an assistant introduce his finger into the abdomen and compress the common iliac artery against the inner border of the psoas muscle.

Lloyd's method of elastic constriction is admirable and is applied as follows: After the extremity has been drained of its blood by elevation, "a strip of black India-rubber bandage, two yards long, is to be doubled and passed between the thighs, its centre lying between the tuber ischii of the side to be operated upon and the anus. A common calico thigh roller should next be laid lengthwise over the external iliac artery. The ends of the rubber bandage are now to be firmly and steadily drawn in a direction upward and outward, one in front and one behind, to a point above the centre of the iliac crest of the same side. They must be pulled tightly enough to check pulsation in the femoral artery. The front part of the band, passing across the compress, occludes the external iliac artery and runs parallel to and a little above Poupart's ligament. The back half of the band runs across the great sacro-sciatic notch, and, by compressing the vessels, prevents bleeding from the branches of the internal iliac artery which pass through this notch. The ends of the elastic band can be held by the hands of an assistant, or bandages may be attached to its extremities and passed across the opposite shoulder and tied; care being taken to prevent the compression rollers from slipping."

Trendelenburg transfixed the soft parts in front of the joint with a steel rod and then compressed the tissues against it by winding an elastic tube about its ends, the figure-of-8 turns passing in front of the thigh. The rod was about fifteen inches long and was provided with a separable lance-shaped point two inches in length. The shaft of the rod was biconvex upon cross-section, one-quarter of an inch in width and a twelfth of an inch in thickness at its centre.

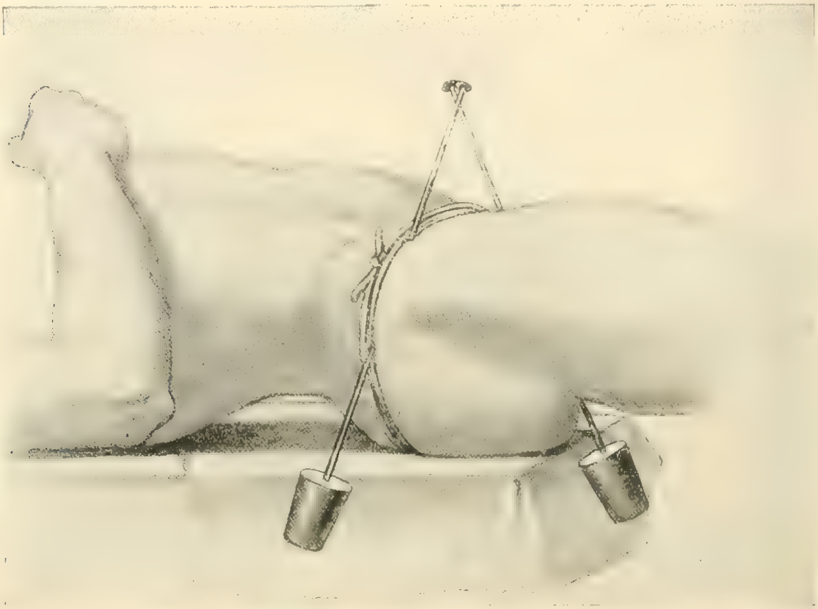


FIG. 199.—Method of Hæmostasis as Applied to an Amputation at the Hip Joint. First stage. Pins and rubber-tube tourniquet are in position. The Esmarch bandage has been removed. (From "Practice of Surgery," by John A. Wyeth, M.D., LL.D., New York, 1908; by permission.)

WYETH'S BLOODLESS METHOD.—(Figs. 199, 200, 201, and 202.)—This is the most valuable improvement made in recent years in the prevention of hemorrhage in this operation. It is almost universally adopted in America at the present time. Affording, as it does, such absolute security from hemorrhage it is difficult to conceive of any condition where other methods should be preferred. Two steel mattress-needles are employed as pins; they should be a foot long and three-sixteenths of an inch in diameter. After the extremity has been drained of blood, either by an Esmarch bandage or by elevation, the first pin is inserted an inch and a half below and slightly to the inner side of the anterior superior spine of the ilium and made to traverse the muscles midway between the greater trochanter and the iliac spine, and to emerge just behind the trochanter. The second pin is inserted to the inner side of the saphenous opening half an inch below the groin, pushed through the adductor muscles, and brought out one inch below and in front of the tuberosity of the ischium. The points of the pins are then protected with corks to prevent subsequent injury. A piece of strong half-inch rubber tubing is now wound tightly about the thigh above the fixation pins. The tubing should be long enough to go around five or six times, and its ends should be either clamped or tied.

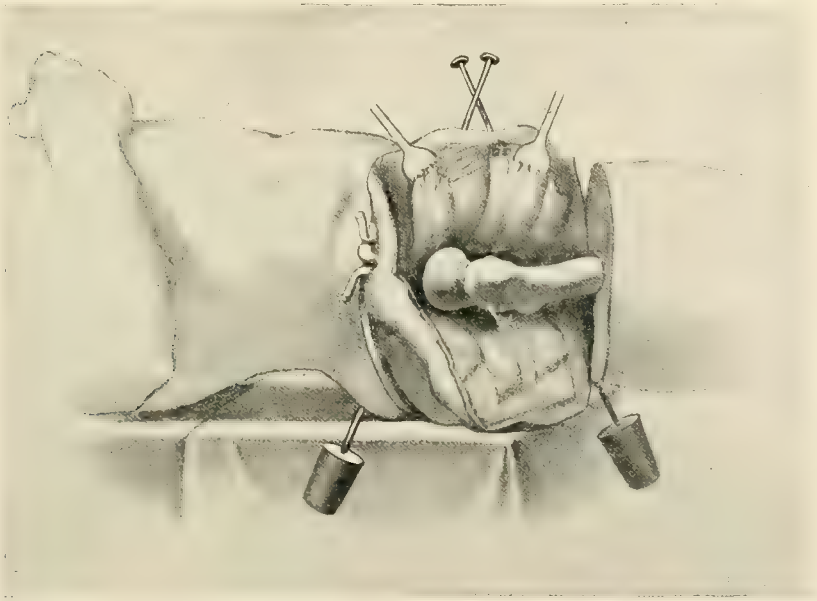


Fig. 200.—Wyeth's Method of Hæmostasis as Applied to an Amputation at the Hip Joint. Second stage. The soft parts have been dissected from the bone and the capsule is exposed. (From "Practice of Surgery," by John A. Wyeth, M.D., LL.D., New York, 1908; by permission.)

Although many varieties of disarticulation at the hip joint have been described, the great majority have fallen into disuse, and only those will be considered here which are in general use at the present day.

The instruments employed are those appliances which are necessary for the application of the elastic tourniquet, a strong amputating knife with a six-inch blade, a strong scalpel, an amputating saw, lion forceps, periosteal elevator, dissecting forceps, hæmostats, scissors, and needles.

After the pins and the elastic constrictor have been applied, as described above, a circular incision is made about the thigh six inches below the tourniquet and extending to the deep fascia.

A cellulo-cutaneous flap is now raised until the level of the lesser trochanter is reached, vertical releasing incisions being made if necessary. The muscles are then divided by a circular sweep of the knife at the base of the reflected flap, and the bone is sawn across at a lower level so as to provide good lever-

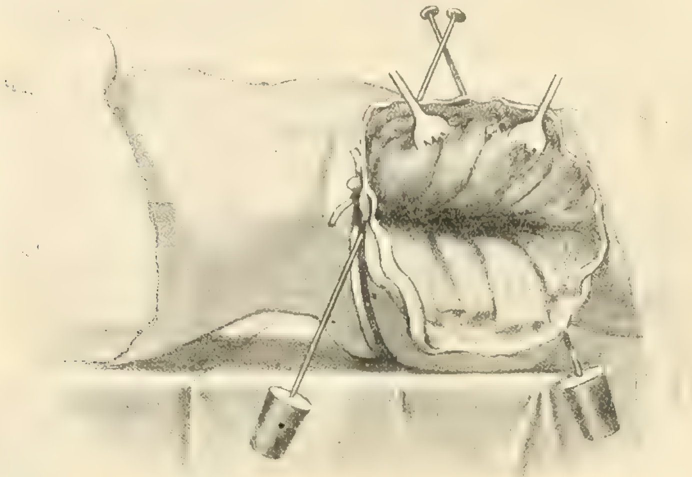


FIG. 201.—Wyeth's Method of Hæmostasis as Applied to an Amputation at the Hip Joint. Third stage. The disarticulation is now complete. The constrictor, however, still remains in position. (From "Practice of Surgery," by John A. Wyeth, M.D., LL.D., New York, 1908; by permission.)

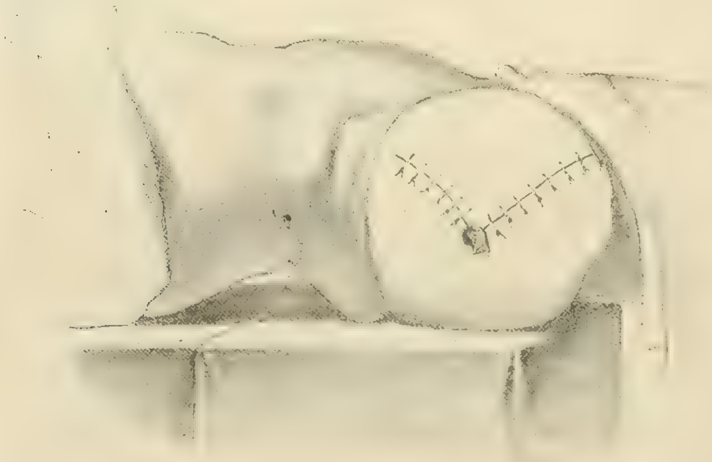


FIG. 202.—Wyeth's Method of Hæmostasis as Applied to an Amputation at the Hip Joint. The operation completed. (From "Practice of Surgery," by John A. Wyeth, M.D., LL.D., New York, 1908; by permission.)

age for the subsequent disarticulation. The large vessels are now tied, the rubber tubing is cautiously loosened, and all bleeding points are seized and ligated. The muscular attachments of the upper end of the femur are next divided, the capsular and cotyloid ligaments are incised posteriorly, and the lower extremity of the bone is carried upward and inward so that dislocation occurs, when the capsular and round ligaments may be divided and the bone removed. The flaps are coapted vertically. The drain should be placed externally and the inner portion of the wound should be specially protected to prevent infection from the urine or the fæces.

SENN'S BLOODLESS METHOD. (Figs. 203 and 204.)—An incision is commenced three inches above the tip of the great trochanter and is carried downward in the long axis of the bone for a distance of eight inches. The insertions of the muscles are severed close to the bone, and the thigh is flexed, forcibly adducted, and rotated inward, after which the upper and posterior part of the capsular ligament is incised. The thigh having now been slightly flexed, the complete division of the capsular ligament is effected. The head of the bone is dislocated outward, and the round ligament divided, or, if this be impossible, the bone is dislocated upon the dorsum of the ilium. The upper portion of the femoral shaft and the lesser trochanter are then well bared and the limb is brought in line with the trunk and slightly flexed. A long and strong forceps is now introduced into the wound, passed behind the femur at the normal level of the lesser

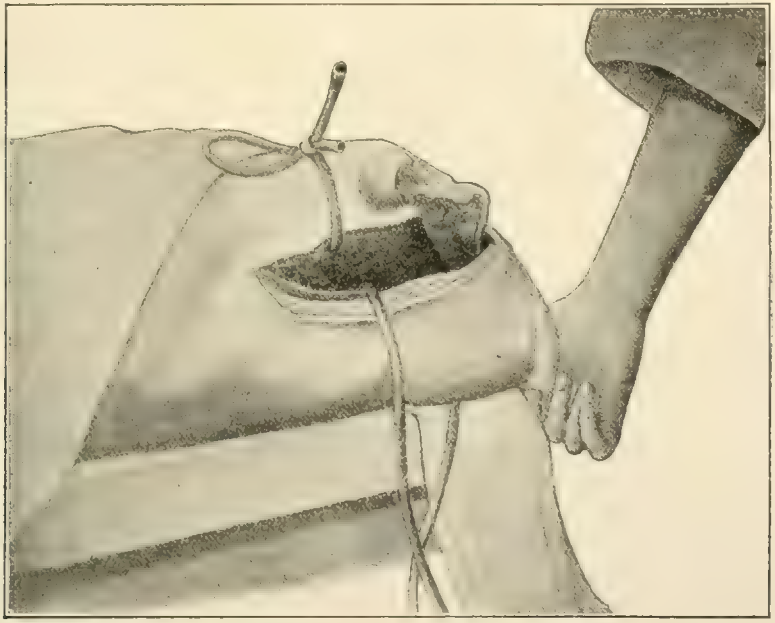


FIG. 203.—Senn's Bloodless Amputation at the Hip Joint. Head of femur dislocated through incision; elastic constrictors in place, anterior one tied. (Copied from "Bryant's Operative Surgery," D. Appleton & Co., New York, 1905; by permission.)

trochanter, and pushed downward and inward to a point immediately behind the adductor muscles and two inches below the tuber ischii. An incision, two inches in length, is made upon the point of the forceps, which thereupon emerges through the opening. A piece of rubber tubing, four feet long and three-quarters of an inch in diameter, is seized at its middle by the forceps and pulled through the tunnel made in the tissues of the thigh. The tubing is cut at the point at which it was seized by the forceps, the intention being to use one-half (at a later stage of the operation) to constrict the tissues in the anterior aspect of the thigh, while the other is similarly to be utilized in constricting those upon the posterior aspect. After the extremity has been drained by elevating the limb, the constricting pieces of tubing are tied and the amputation is completed in the usual manner.

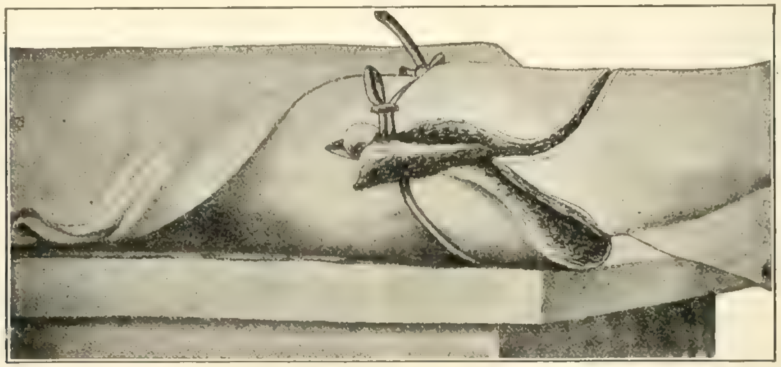


FIG. 204.—Senn's Bloodless Amputation at the Hip Joint. Elastic constriction completed; antero-posterior flaps formed of all tissues down to muscles. (Copied from "Bryant's Operative Surgery," D. Appleton & Co., New York, 1905; by permission.)

DISARTICULATION THROUGH AN EXTERNAL RACQUET INCISION. (Fig. 196.)—The pelvis of the patient rests upon the edge of the table. The surgeon stands to the outer side of the thigh, facing the patient. The circulation having been completely controlled, the thigh is adducted, slightly flexed, and rotated inward. The knife is inserted two inches above the tip of the great trochanter, and a vertical incision is carried downward along the posterior border of the trochanter for a distance of seven inches. From the lower extremity of this vertical cut a crescentic incision is carried across and to the back of the thigh, the two incisions being of the same length and meeting internally at a lower level than that at which they were started. The entire incision involves only the skin and superficial fascia. The flap which encircles the limb is next dissected up for a distance of two inches in the same manner as that practised in an ordinary circular amputation. After the thigh has again been flexed, adducted, and rotated inward, the vertical incision is deepened down to the bone, and the muscles attached to the great trochanter are divided close to it. The upper portion of the shaft of the femur, in the depths of the vertical incision, is thoroughly bared, care being taken to avoid injuring either the femoral or the profunda artery. These steps involve the division of the insertions of the gluteus maximus, quadratus femoris, psoas, iliacus, pectineus, and the superior fibres of the adductor magnus and quadriceps extensor muscles. The limb is now strongly adducted and the capsule is transversely divided at the upper and posterior part. The limb is next slightly flexed while the anterior part of the capsule is incised, and is finally rotated outward while the remaining fibres of the capsule and the round ligament are divided and the head of the bone disarticulated. The muscles upon the inner aspect of the thigh are then cut by a circular sweep of the knife at the level of the base of the reflected flap and the extremity is removed.

The femoral and profunda vessels are secured in the anterior portion of the wound close to the cut ends of the rectus, sartorius, and adductor longus. After the large vessels have been ligated the internal circumflex is picked up at the inner and posterior aspect of the acetabulum. The descending branch of the external circumflex is situated near the inner margin of the vastus externus. The comes nervi ischiadici, as well as many other branches of the sciatic and muscular branches, will also require ligation.

The advantages of the external racquet method are the following: The drainage is good, the wound is away from the anus, and the ischium (the main point of future support) is well covered; shock is diminished by the low division of the soft tissues, and but little injury is inflicted upon the branches of the sciatic and gluteal arteries; the main artery is divided in the latter part of the operation; the vertical incision exposes the femur through the least vascular portion of the thigh and is so situated that an excision may be performed if a careful examination shows that an amputation is unnecessary.

This method is practically identical with the first hip-joint amputation planned by Ravaton in 1743. Kerr's amputation in 1778 was also a similar procedure, although his external incision was in the shape of an inverted V. The names of many surgeons have been associated with the method, and the following are its chief exponents: Lister, Furneaux Jordan, and Esmarch.

Lister's Amputation.—This procedure is founded upon the principles of Furneaux Jordan's operation, which will be next described. Lister made the vertical incision eight inches long and divided the muscles circularly before clearing the femur, the disarticulation being left until the termination of the operation.

Furneaux Jordan's Amputation. (Fig. 205.)—Next to Wyeth's this is perhaps the safest and simplest of all methods of disarticulating at the hip joint, and furthermore it requires no special instruments or apparatus for its performance. The circulation is controlled by an Esmarch's bandage. The thigh is amputated near its middle by the circular method, the bone being left unsawn so as to offer a more efficient lever. The vessels having been secured, the bandage is next removed, and a vertical incision extending up to a point midway between the trochanter and the crest of the ilium is made on the outer non-vascular side of the limb. Disarticulation is now effected by cutting the ligaments and muscles down to their insertion. Only a few minor arterial branches are cut in the second stage of the operation. The stump is to be closed both vertically and transversely. Drainage should be employed. Furneaux Jordan's method is not applicable to all cases, and in malignant disease it is distinctly inferior to Wyeth's method.

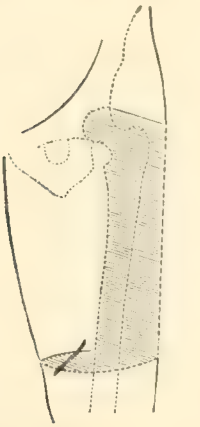


Fig. 205.—Furneaux Jordan's Amputation at the Hip Joint. The shaded part represents the area traversed by the knife; the dotted lines the incision. (From Treves' "Operative Surgery.")

The first hip-joint amputation performed in America, and the first successful one in the world, was carried out practically in accordance with this method; Brashear, of Bardstown, Kentucky, in 1806, amputated the thigh of a colored boy in the lower third, and then followed this by enucleating the bone through a long external incision.

Some of the best and more modern methods have retained all of the essential features of Jordan's method, and have added just enough to warrant the use of a different name.

The occasional operator, who has not the best assistants and who is not provided with Wyeth's pins, should give the preference to the Furneaux Jordan method. The resulting stump, it must be admitted, is less shapely than that obtained by some of the other methods.

Esmarch's Amputation.—In this procedure all the soft parts of the thigh are severed by a vigorous circular sweep of the knife five inches below the great trochanter, and the bone is sawn across at the same level. The vertical incision is now made, the upper extremity of the femur is steadied with a lion-jaw forceps, and disarticulation is accomplished in the usual manner.

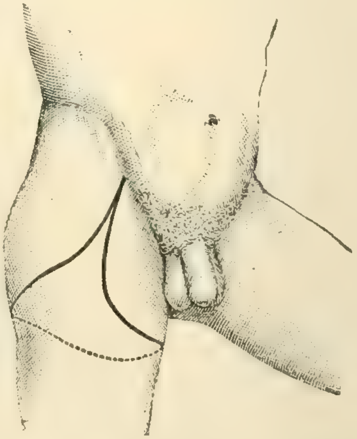


Fig. 206.—Disarticulation at the Hip Joint by an Anterior Racquet Incision. (From Treves' "Operative Surgery.")

Disarticulation through an Anterior Racquet Incision. (Fig. 206.)—Although not so easy of execution as the lateral racquet method, this procedure has the advantage that no tourniquet or hæmostatic appliance is required, since all the large blood-vessels are ligated before division.

The incision commences at the centre of Poupart's ligament and follows the line of the vessels for a distance of about three inches. It curves inward, crossing the adductors four inches below the genito-crural junction, passes over the back of the thigh, somewhat below the base of the great trochanter, and curves obliquely across the front of the thigh to join the vertical incision about two inches below its starting-point. The upper part of the incision is deepened and the common femoral artery is exposed and divided between two ligatures. The common femoral vein is similarly ligated at the same level. The border of the entire flap is now liberated and allowed to retract, although it is not dissected up. The sartorius, the rectus, and the tensor vaginæ femoris are next cut, and upon their retraction the exposed external circumflex artery is divided between two ligatures. The limb is now rotated inward while the insertion of the gluteus maximus is divided, and is then rotated outward while the psoas is cut. The internal circumflex vessels are next exposed and secured. The muscles upon the inner aspect of the thigh are then cut at the level of the retracted skin. With the thigh adducted and rotated inward, the muscles attached to the great trochanter are severed, after which the limb is abducted and rotated outward to allow of transverse division of the capsule, disarticulation of the head of the bone, and division of the round ligament. At this stage the obturator externus tendon is divided. The external rotation of the limb is now exaggerated, the head of the femur is held forward, and all of the soft parts on the back of the thigh are divided by a vigorous sweep of the knife at the level of the retracted skin.

The advantages of the anterior racquet method are: No form of elastic constriction is necessary; the main blood-vessels are secured early in the operation; the hip joint is well exposed and disarticulation is easy; and the ischium is well covered.

The objections to this method are the following: The femur is exposed by an incision that traverses a vascular area; the incision is not well adapted for excising the hip joint should the amputation be abandoned; and the drainage is not so good as in the external racquet method.

DISARTICULATION BY ANTERO-POSTERIOR FLAPS, CUT BY TRANSFIXION.—This rapid and brilliant method is now obsolete since its "raison d'être" vanished with the introduction of anæsthesia. No tourniquet was employed, the anterior flap was the longer, and the main vessels were compressed in the flap by a deft assistant before they were divided. The method is open to all the objections attendant upon transfixion in general.

GUTHRIE'S AMPUTATION BY ANTERO-POSTERIOR FLAPS, CUT FROM WITHOUT INWARD.—This procedure is but slightly inferior to either of the racquet methods. No less an authority than Ashhurst regarded it as the best method of amputating at the hip.

The surgeon stands at the right side of the limb to be operated upon. Both flaps should be about five inches long, and it is advisable to cut the posterior one first. The incision commences just above the great trochanter, passes downward and inward in a curved manner across the back of the thigh, and then upward and inward, to terminate just below the tuber ischii. The anterior flap is now marked out in a similar manner. After retraction of the tegumentary flaps the muscles are divided obliquely from below upward in the line of the original incision. Upon exposure of the joint, disarticulation is effected in the customary manner. The superficial and deep femoral vessels should be secured by ligatures before they are divided.

The resulting stump is serviceable and the cicatrix is small and admirably placed.

MORTALITY STATISTICS.

An exhaustive or even a systematic presentation of the mortality statistics of amputation is not contemplated here. We give some of the more important data that have been secured by other investigators in this field.

Statistical Report of 703 major amputations from the records of eight hospitals of New York City, by John F. Erdmann. *Annals of Surgery*, Vol. XXII., pp. 358–362, July–Dec., 1895.

	Amputations.	Deaths.	Per cent.
Wrist	7	0	0.
Forearm	71	1	1.4
Elbow	6	0	0.
Arm	88	16	18.
Shoulder	24	6	25.
Foot	64	5	7.8
Leg	156	19	12.
Knee	46	6	13.
Thigh	223	48	21.5
Hip	18	8	44.4

Cases in Bellevue.

	Freshly Traumatic Cases.	Average Age.	Deaths.	Average Age at Death.	Per cent.
1884–1889	47	34	12	43	25.5
1889–1894	20	35	4	58	20.

All Single Amputations at Bellevue.

	Cases.	Deaths.	Per cent.
1884–1889	114	19	16
1889–1894	61	9	14

F. Murphy's Table; Division of Surgery, Med. School, Harvard Univ., Bull. III., September, 1904. Record of 500 cases of amputation, Massachusetts General Hospital.

LOWER EXTREMITIES.

	Total.	Died.
1. For crush.—(Single.)		
Thigh	66	27
Leg	172	8
Foot (partial)	32	1
(Double.)		
Thigh	1	..
Thigh and tibia	11	2
Thigh and partial	1	..
Tibia	19	6
Tibia and partial	5	1
2. For bad stumps.		
Thigh	11	..
Leg	35	1
Partial	6	..
3. For sepsis.		
Thigh	11	4
Leg	4	1
4. For gangrene.		
Thigh	31	11
Thigh and leg	1	1
Leg	23	12
Partial (double)	1	..
5. For new growth.		
Double thigh	1	1
Thigh	32	5
Leg	12	2
6. For tuberculosis and osteomyelitis.		
Thigh	17	1
Leg	6	..
Partial	1	..
Totals	500	84

According to von Bergmann's "System of Surgery," Vol. III., the mortality of amputations at the hip joint, of interscapulo-thoracic amputations, and of amputations of the upper arm, is as follows:

Hip joint—preantiseptic period—70 per cent. Subsequently it has been placed at 29 per cent by one authority (Coronai) and as low as 13 per cent by another (Riedel).

Interscapulo-thoracic.—Up to 1899, for tumors, 96 per cent immediate recoveries; mortality 4 per cent (Koenitzer).

Upper Arm.—Operative mortality, *nil.*

W. L. Estes, Surgeon-in-Chief of St. Luke's Hospital, South Bethlehem, Pa., gives the following statistics in his article entitled: "A Further Contribution to the Study of Modern Amputation," *American Medicine*, Nov. 29th, 1902, p. 859.

List of Amputations for the last eight years; single major amputations.

	No. of Operations.	Deaths After Operations.	Mortality Percentage.	Remarks.
Amputation of arm	13	..	..	
" at elbow joint	2	..	..	
" of forearm	17	..	..	
" " foot, Chopart's	4	..	..	
" " " Hay's	3	..	..	
" " " Mikulicz's	2	..	..	One done for disease
" " " Syme's	5	..	..	
" " leg, lower third	32	..	..	
" " " middle third	14	..	..	One for disease.
" " " upper third	1	..	..	
" " thigh, lower third	36	..	..	
" " " middle third	8	1	12.5	
" " " upper third	5	2	40.	
" " at hip joint	4	2	50.	One had pyæmia when admitted and was very low. The other died of acute anæmia.
" " " knee joint	9	..	..	
" " " shoulder joint	9	..	..	
Totals	164	5	3.04	

He also gives tables of complicated, double, triple, and quadruple operations. Complete list of single major amputations for twenty years.

	No. of Operations.	Deaths After Operations.	Mortality Percentage.	Remarks.
Amputation of arm	40	1	2.5	
" " elbow joint	2	..	..	
" " forearm	54	..	..	
" " foot, Chopart's	11	..	..	
" " " Hays'	5	..	..	
" " " Mikulicz's	2	..	..	
" " " Pirogoff's	1	..	..	
" " " Syme's	14	..	..	
" " leg, lower third	79	1	1.26	
" " " middle third	42	..	..	
" " " upper third	20	1	4.34	
" " thigh, lower third	80	5	6.25	
" " " middle third	33	3	8.48	
" " " upper third	13	3	23.07	
" at hip-joint	11	3	27.27	
" " knee joint	26	1	3.84	
" " shoulder joint	22	1	4.54	
Total number	458	19	av. 4.12	

Wyeth, John A. Amputation through the hip joint, with a synopsis of 267 cases in which the author's method was employed. *Journ. Am. Med. Assn.*, 1901 - May 18th, p. 1361 *et seq.*

P. 1372: "Of the 267 cases of disarticulation at the hip joint for all causes, herewith reported, 53, or 19.8 per cent, died. . . . In Ashhurst's 'Internat. Encyclopedia of Surgery,' 1881, F. C. Shepperd gives, to that date, a total of 663 cases of amputation through the hip for all causes, with a mortality ratio of 64 per cent. In *Lancet*, March 5th, 1892, F. Page gives 16 cases in which the amputation was done by other methods in Royal Infirmary, Newcastle-on-Tyne, with a ratio of mortality of 37.5," etc., etc.

Coley, Wm. B.: Trans. Southern Surg. and Gynecol. Assn., 1903, p. 77: Seven cases of amputation at hip joint for sarcoma without mortality. Wyeth's method of wire pins was used in all but one case.

W. W. Keen and J. C. DaCosta: A case of interilio-abdominal amputation for sarcoma of the ilium, and a synopsis of previously recorded cases. *International Clinics*, Vol. IV., 13th Series, Phila., 1904, p. 127.

Table of 19 cases of operation in which the termination is known, with 5 recoveries, the first being in 1889 or 1891. This patient died 33 hours after the operation.

In an article by K. Cramer, in the *Archiv f. Orthopaedie*, 1905, iii., p. 101, on diaphysis stumps of the thigh and leg, the following data are given:

Preantiseptic Period.—Leg amputations, mortality 40 per cent; thigh amputations (Pitha-Billroth), 45 per cent–50 per cent; Crimean war, 91 per cent; American war, 64 per cent.

Antiseptic Period.—Mortality fell to 16 per cent, according to Oberst; while, according to Gordon-Kljadschko, the mortality in 1,413 cases (1890–1899) was only 9.5 per cent.

Cramer himself operated in 96 cases—46 in thigh and 50 in leg—without mortality.

Farrar Cobb, in the *Annals of Surgery*, XLI., p. 267, makes the statement (in the course of his report of a case of interscapulo-thoracic amputation for sarcoma of humerus) that "but 5 such operations, his own included, have been recorded at the Massachusetts General Hospital since 1870."

In a report before the Soc. de Chirurgie, Paris, 1905, XXXI., Berger reviews a work by Jeanbrau (Paris, 1887) on interscapulo-thoracic amputation of the arm for tumors:

Jeanbrau and Riche collected 188 observations from 60 surgeons. The mortality was 11.1 per cent. But, while the operations performed before 1887, or when the technique was imperfectly developed, showed a mortality 29.16 per cent, those performed after 1887 showed one of only 7.84 per cent. If cases in which intervention was contra-indicated are left out, the figures could be reduced to 5.2 per cent. Of 125 cases in which the nature of the new growth had been determined by a microscopic examination, recovery followed in 105. Of the 20 others, 10 died from operation, and reports about another 10 could not be obtained.

ARTIFICIAL LIMBS.

General Considerations.

It has already been stated that improvements in the construction of artificial limbs has materially modified several methods of amputating, so that what were formerly useful amputations are now better replaced by others which may involve a greater destruction of tissue. On the other hand, these same improvements have made it possible to conserve tissues in some cases. Thus, for example, in amputation of the leg the junction of the upper and middle thirds is no longer the site of election, but the junction of the middle and lower thirds has become the chosen point, amputation at the latter level permitting the adjustment of a limb which is not only more comfortable, but also better suited to support the weight and maintain the equilibrium of the body. As regards the partial amputations of the foot it may be stated that, with few exceptions, it is better to amputate above the ankle, through the junction of the lower with the middle third of the leg, for the reason that better functional results can be obtained.

One of us has on two occasions performed Lisfranc's operation with perfect satisfaction, and each patient was subsequently able to walk and dance as well as before. Both wore ordinary shoes with the anterior portion built up. Neither patient limped and no one would have suspected that a portion of the foot had been sacrificed.

Our results have not been satisfactory after Chopart's amputation, which removes but a little more of the member than Lisfranc's, and we no longer practise it.

We are informed by those who make and adjust prosthetic appliances that a very satisfactory foot can be adjusted after Syme's amputation.

The old amputations of Chopart and Liston are particularly ill-suited for the procurement of good functional results, inasmuch as the action of the extensor tendons is destroyed, so that the tendon of Achilles is likely to elevate the heel. These considerations seem to us to be of the utmost importance, for not only do we hear the occasional operator still discuss the relative merits of the antiquated partial amputations of the foot and speak of the junction of the upper with the middle third of the leg as the point of election, but we know that the same errors are being perpetuated by some teachers of surgery. Another matter concerning which there seems to be much doubt is the time at which an artificial limb should be applied; and the question is also asked, How should the stump be prepared for its reception? As a rule, it may be stated that three months will suffice to put the stump in proper condition for the reception of artificial limb. In many instances the limb may be applied earlier than this after amputation. There are no objections to this course, provided the condition of the stump is satisfactory. The important prerequisite is that all inflammation shall have disappeared. Formerly, when wooden legs were in vogue, a much longer time was required than at present. As soon as complete healing of the stump has taken place a firm bandage should be applied, and over it there may advantageously be applied a "shrinker"—a device made by artificial-limb manufacturers and intended to reduce the stump. The shrinker also serves to hold the bandage in place, and, morever, it affords protection in case the patient falls or slips. It is of great importance that the stump be kept scrupulously clean, and for this purpose bathing with cool water, followed by a brisk rubbing with a suitable fluid, should be resorted to at least once a day. While it is desirable that as much pressure as possible be exerted upon the stump, so that its size may be reduced without undue delay, care should be taken not to apply the bandage or shrinker tightly enough to interfere with the circulation or produce pain. The object is to hasten atrophy of the soft parts—a change which is certain to take place in course of time,—but not to impair the nutrition of the part.

In regard to artificial limbs themselves it may be of interest to trace their evolution through various ages and to mention some of the more important modifications which have been made in their construction. Artificial legs were made at a very early period, as shown by the fact that one was exhumed at Capua along with a skeleton and some vases—the latter supposed to be of the year 300 B.C. Herodotus mentions a soldier who wore a foot of wood. Exactly what the mechanism of this member was is not stated. It is said that in the early part of the sixteenth century a Nuremberg mechanic made an artificial hand for a German knight. Later in the same century Ambroise Paré made use of the peg leg and also employed iron hands. In 1696 Verduin, a Dutch surgeon, invented an artificial leg that was provided with an artificial foot to which were fastened two strips of steel extending to the knee. This artificial limb also had a copper socket in which the stump rested. Connected to this socket by two steel side joints was a leather strap which was fastened around the thigh, thus taking some of the body weight off the stump.

Patents for wooden limbs were procured in 1790 and in 1810 by Thomas Mann, and in 1800 by James Potts, both of England. The Potts leg was worn by the Marquis of Anglesea, who lost his leg at Waterloo, and consequently it came to be known as the Anglesea leg. It consisted of a wooden socket for the stump, a steel joint for the knee, and a wooden one for the ankle.

In 1839 William Selpho, who had worked with Potts, introduced the Anglesea leg into America, manufacturing it in New York. He made the knee joint of two steel plates—the upper one being convex, the lower one concave—and covered it with leather. At the ankle he placed India-rubber buffers to prevent concussion.

In 1846, 1849, and 1852 patents were secured by B. F. Palmer for improvements which had for their object the reduction of the weight of the artificial limb and the simplification of the mechanism of the ankle joint.

To avoid chafing the stump, it is necessary that there be no free lateral movement, and, as it is nearly impossible to fit a stump in this way, the wearer may be subjected to discomfort, if not actual suffering, as the changes in the stump due to shrinkage take place.

A few makers have tried, and with some degree of success, to obviate this trouble. As the result, we have the slip-socket legs, the object of which is to lessen chafing and to break the jar in stepping. The slip (or upper section) is held at the point of desired elevation by springs applied in different ways, so that, when the wearer places his weight upon the leg, the springs will allow him to settle to the point of check (a distance of from half an inch to one inch below) with but little jar to the stump.

While these have their meritorious features, they also have objectionable points that are common to all limbs with added mechanism. Frequent repairs are necessary. Moreover, natural walking is not secured. If the artificial limb corresponds in length with the natural leg, the foot will scrape the ground whenever it is swung naturally under the body.

A wooden leg, with its upper part of soft leather, laced in the back for adjustment, is also used. The fault of this socket lies in the fact that, when pressure is brought to bear, the leather will not permanently retain the cavities placed therein to accommodate the irregular bone structure, and will, therefore, cause chafing at the prominent points. Artificial limbs made of specially prepared sole leather compressed and hardened upon a model of the stump, reinforced with hard rawhide, and supplied with a vent inserted to allow ventilation, are said to be satisfactory, especially when the other mechanism is properly adjusted.

In regard to artificial arms and hands it must be admitted that their greatest value is ornamental. The natural mechanism of the hand is too complex to admit of its substitution by any artificial device. However, the hands with ductile fingers and palm lock make it possible for a knife or fork to be held or a package carried.

The more or less continuous improvement in the material and mechanism of all prosthetic appliances is best utilized, by those who are in need of their benefits through consultation with their respective surgeons and by conferring with the wearers and studying the various reports and the catalogues of makers of these appliances.

EXCISIONS OF BONES AND JOINTS.

By HORACE J. WHITACRE, B.S., M.D., Cincinnati, Ohio.

GENERAL CONSIDERATIONS.

THE terms "excision" and "resection" are properly applied to specific surgical procedures, yet modern writers have used them largely as synonyms. The term "excision" is rightly applied to any operation that is undertaken for the removal, in continuity, of a segment of tissue, without the total ablation of this portion of the body, a procedure for which the term "amputation" would be appropriate; but when the word is used by itself, in its more restricted surgical sense, it is intended to signify an "operation for the removal, partial or complete, of an injured or diseased articulation, or of a bone, and generally one of the flat or short bones, which can be removed entire without jeopardizing the usefulness of the affected part." (Ashhurst.)

The term "resection" is properly applied to an operation which removes a segment of the shaft of a long bone and perhaps brings the two ends together.

History of Excisions and Resections.—Excisions and resections were certainly understood theoretically and perhaps practised to a limited degree by the ancients, as would be indicated by the fact that Hippocrates, Galen, and Celsus have all spoken of removing the protruding bone when reduction could not be accomplished in a compound dislocation, and have also referred to the removal of protruding bone ends in compound fractures. Brief references are made to this procedure in the works of many subsequent writers of ancient times, but such operations did not become matters of definite record until about the middle of the eighteenth century.

Mr. Filkin, in 1762, performed the first recorded excision for disease, and Mr. Winman, of Shipton, excised the lower end of the humerus for compound dislocation a few years earlier. Many successful individual cases were reported after this, but the credit of definitely presenting the advantages of excision, as a substitute for amputation in tuberculous arthritis, is due Mr. H. Park, of Glasgow, who performed his first operation in 1781. Moreau, in France, had worked independently along the same lines, but his recommendations did not meet with acceptance. The operation nowhere gained particular favor for many years. The real acceptance of the method in Great Britain is attributed to Mr. Syme, of Edinburgh, who wrote in 1826, and Sir William Fergusson, who wrote from 1845 to 1851. John C. Bigelow, Gurdon Buck, Sayre, Harris, Pancoast, Kinloch, and Andrews in America were early advocates of excision. The later developments of the procedure are to be attributed to those men whose names appear so frequently as originators of the methods which are discussed in the following pages.

Nature and Purposes of Excisions.—As has already been stated, the terms "excision" and "resection" are often used interchangeably and are applied to the operation of removing a part or the whole of a bone or joint for injury or for disease. The operation of excision is a conservative measure which is to be undertaken in those cases where a bone or joint has suffered injury or disease of a nature which will in itself cause permanent loss of the structure, and thus lead to continued illness or impairment of function, or to deformity; where a local extension or a general dissemination of a local process is to be feared; where deformity already exists; where joint function may be restored; and, lastly, in all cases where amputation of the extremity is the alternative. It may be performed in the shaft of the bone or at either end of one or more bones. The excision, if of a joint, is said to be *complete,* when the heads of all bones entering into the articulation are removed; or it is spoken of as *partial,* when the articular end of but one bone, or a portion of one bone, is removed, the ends of the bones being sawed off at varying distances from the end. The term *erasion* or *arthrectomy* is applied to the removal, by dissection, scraping, or gouging, of diseased structures composing a joint. In this operation the bone ends are not sawed off and the general contour of the head of the bone remains the same.

The question whether it is best to follow a non-operative course of treatment, our chief dependence being placed upon such measures as immobilization and improved surroundings, or to excise, or, finally, to amputate, is often a very difficult one to decide. It should always be remembered, in favor of the first of these plans, that complete rest (immobilization) in any disease of bone or joint is a therapeutic agent of very great value. Under the beneficial influence of rest, fresh air, and good food, the vital regenerative powers of the body will sometimes accomplish the most conservative results that can be obtained—results which are better than those obtainable by operation. The patient should therefore always be given the benefit of these well-established facts, provided the case be one in which the existing conditions justify such a hopeful outlook. Among the facts which favor excision, the following may be mentioned: (1) First, the determination to excise will be made in many cases after well-directed efforts along conservative lines have failed to arrest the disease, or when such treatment has left a functionless or a badly deformed articulation. (2) The social status of the individual or his surroundings may be such that a conclusion in favor of excision is easily reached at the onset of the disease. This is possibly true, for example, in the case of a patient with a tuberculous joint whose family is dependent solely upon his daily wages for their support. It is manifestly impossible for this patient to carry out efficient immobilization for a period of two or more years, nor can he command the dietetic or hygienic elements essential to a cure. He must return to work at the earliest possible moment and may therefore choose excision. (3) The nature of the local disease may be such as to demand excision at the onset, there being no grounds for the belief that a non-operative course of treatment would accomplish good. This is often true, for example, in cases of bad deformity, of ankylosis, and of injury to a joint. (4) The decision to operate will often depend upon the occupation of the individual or possibly upon his oversensitiveness to deformity.

The operation of excision may be classed as one that is comparatively safe; and by means of it one may expect to obtain a useful, or stable extremity, with or without the use of supplementary apparatus.

When the question is whether to excise or to amputate, excision assumes the character of a conservative measure, and the advantages of saving an extremity are so plainly apparent that the decision is generally in favor of this operation. Furthermore, the saving of the limb is an argument which appeals strongly to the patient. There is another factor, however, which has to be very carefully considered before a final decision is reached; I refer to the prospective usefulness of a limb thus saved.

The Process of Repair after Excision.—The nature of the process of repair will depend naturally upon the type of excision performed. When a subperiosteal excision has been performed there will be a prompt proliferation of the inner layers of the periosteum and a more or less complete restoration of the removed bone. This process will be associated with a normal connective-tissue repair in the wound, and in the end there will be, in the case of excision of a joint, a definite regeneration of the ends of the bone, which will be bound together by a strong but flexible fibrous band. This band of fibrous tissue fills in the gap between the bones and holds them firmly together. Its flexibility makes possible the movements that are expected after a typical excision.

When a segment of a long bone is removed subperiosteally, it is expected that ultimately complete regeneration of the bone will take place.

When a small bone, such as one of the carpal or tarsal bones, is removed, the space left is usually so entirely filled in by scar tissue that neither deformity nor interference with function results.

When a non-subperiosteal excision is done, the repair is almost purely one by granulation or scar tissue.

Instruments Required.—The instruments for excision are illustrated in Fig. 207. The knives, scissors, thumb-forceps, and artery clamp used should be of heavy construction. There should be at least two knives, since it is necessary to have a very sharp knife at certain stages of the operation, particularly when operating for disease. Tuberculous tissue should be removed by sharp dissection, and it is necessary to lay aside the knife which has been

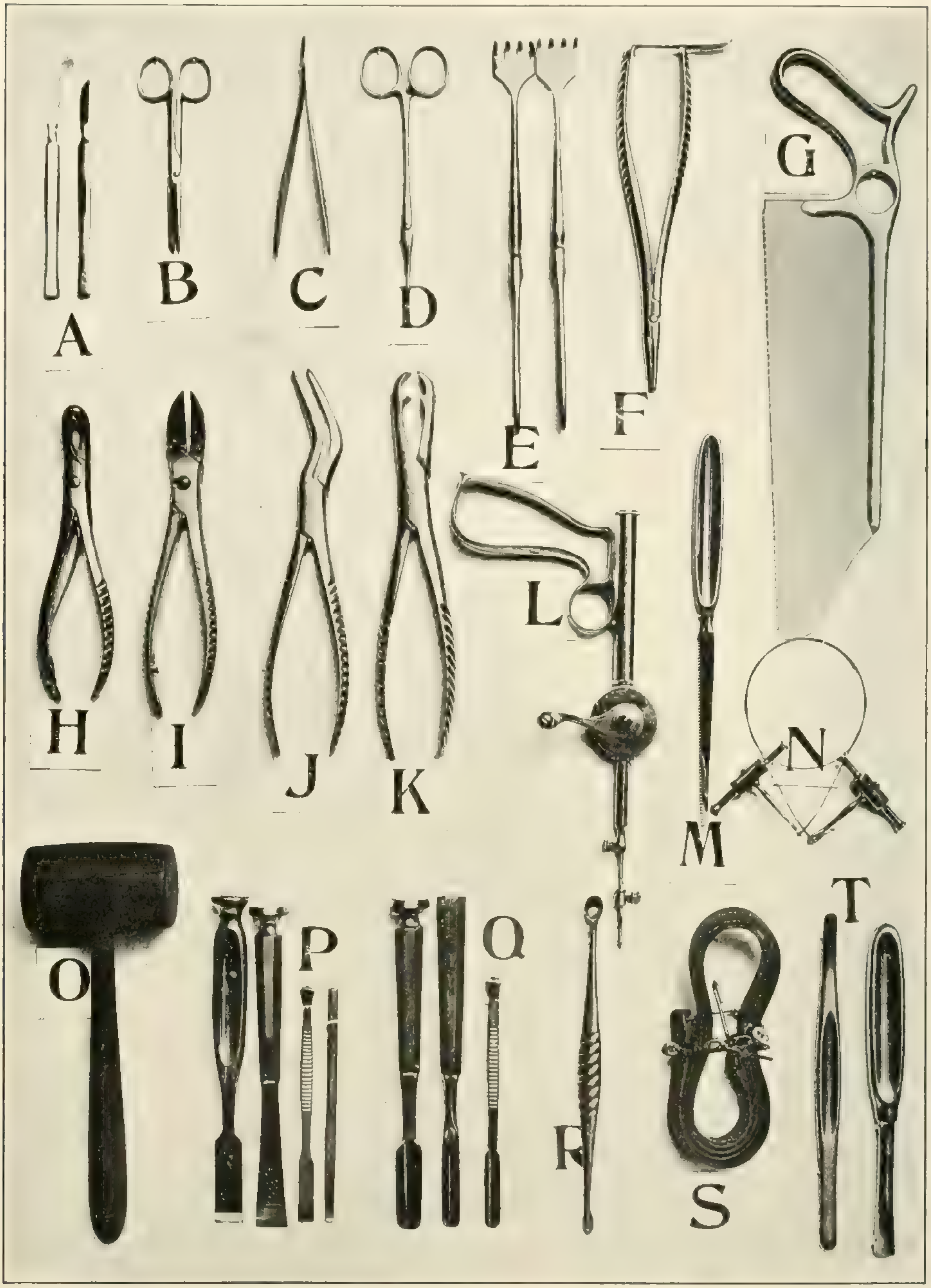


FIG. 207.—Instruments Used in Excisions and Resections. *A*, Scalpels; *B*, scissors; *C*, thumb forceps; *D*, Kelly hæmostatic forceps; *E*, sharp hook retractors; *F*, McBurney's needle-holder; *G*, saw; *H*, rongeur bone-forceps; *I*, Liston's bone-cutting forceps; *J*, sequestrum forceps; *K*, Ferguson's lion-jaw forceps; *L*, bone drill; *M*, metacarpal saw; *N*, Gigli wire saw; *O*, wooden mallet; *P*, chisels; *Q*, gouges; *R*, Volkmann's bone-curette; *S*, Esmarch's tourniquet; *T*, periosteal elevators.

dulled by contact with the bone when this sharp dissection begins. A strong knife should always be at hand for cutting away bone foci. Both sharp and blunt retractors should be at hand, the latter being quite necessary when tendons and nerves are to be pulled aside. Any one of the great variety of saws may be used. The author has found the Gigli saw rather unsatisfactory because of its tendency to break, yet there are times when it is quite indispensable, since it is possible by its use to saw off a bone without serious displacement of important soft tissues. Chisels and gouges of all sizes are important elements in the collection and should be at hand whenever a joint is attacked. Particular care should be given to the choice of a tourniquet. Broad rubber bands, that give uniform pressure over a considerable area, are much to be preferred to a cord. The tourniquet must often remain in place for a considerable period of time; and paralysis is apt to follow when a sufficient pressure is used with a narrow band. Special instruments are required for operations such as temporary osteoplastic resection of the skull.

The Operation.—The incision made for the exposure of the parts in any operation for excision must be planned to give maximum working space, to inflict a minimum injury upon important anatomical structures, and to provide good drainage. The direction of the incision will be longitudinal, as a rule, yet may be variously modified; H-, V-, or bayonet-shaped incisions being employed to meet special requirements. The incisions are invariably placed at a point where important tendons, nerves, or arteries will not be divided, and they should be of liberal length. If tendons must be divided, they should be cut obliquely and carefully reunited. The treatment of the bone presents problems of the greatest weight. Whenever it is possible, the bone ends should be exposed by a straight incision through the periosteum and removed subperiosteally. It is a matter of accepted importance that the bony prominences giving attachments to muscle tendons usually should not be chipped off during the dissection, even though they are a part of the bone which is diseased. The reason for allowing them to remain is that they give greatly increased stability after healing has taken place. These bony prominences are usually not diseased, even in tuberculosis. The subperiosteal method of excision gives results that are so distinctly superior to the non-subperiosteal method that this point cannot be disregarded in the cases in which this method is practicable. Unfortunately, in the majority of cases the application of the method is not practicable. For example, in cases of tuberculous or malignant disease and in severe injury it will usually be impossible to adopt the plan.

The extent to which the bone should be excised will depend entirely upon the particular joint involved, the nature of the disease, and the result desired. When an entire articulation is removed we speak of it as a complete excision; and if this is done after some well-established method, we term it a formal or typical excision. When the end of but one bone or a portion thereof is removed, we speak of it as a partial excision; and, since the operation is adapted to the peculiar conditions of the case, it may also be called an informal or atypical excision.

One of two results is desired in either a complete or a partial joint excision. The operation is undertaken either for the purpose of obtaining a firm bony union which will convert the bones forming the articulation into a single weight-bearing shaft (as in resection of the knee), or for that of preserving slight or extensive motion in the affected joint (as in excision of the inferior maxilla, the shoulder, the elbow, or the wrist). The questions of the amount of bone to be removed and of the performance of a partial or a complete excision will, in most cases, have to be decided, in large measure, in accordance with the nature of the morbid condition and the result which it is desired to obtain. Motion will be more certain and shortening will evidently be less marked after partial than after total resection, and these facts have led to an increasing tendency to do the partial operation whenever the conditions will permit. A perfected aseptic technique and improved methods of management after operation have made the partial excision possible, and results can now be obtained that were not formerly feasible. The development of the operation of arthroplasty for the treatment of ankylosis has still further increased the field of application of atypical excision of the joints.

When a bone is resected for the purpose of exposing deeper structures, as in operations upon the brain, the operation is spoken of as a temporary resection. For this purpose a horseshoe- or inverted-U-shaped bone flap, together with all attached soft parts, is turned down in order to expose the underlying structures, after which the parts are returned to the former position, where they usually reunite with the adjacent portions.

When a long bone is excised in part or in its entirety, the incision is made in the long axis of the bone and usually in a line where the bone is subcutaneous or quite near the surface. If the bone does not lie near the surface—as, for instance, on the outer side of the thigh for excision of the femur,—then the incision should be at a point where important structures will not be divided. A great length of a functionally important bone should not be excised, unless it can be done subperiosteally, or unless it can be supplemented by the grafting of either a parallel bone or bone from an outside source. In young patients, and to a surprising degree in older patients, there will be a sufficient regeneration of bone from the periosteum to furnish an adequate bony structure. A full appreciation of these facts of regeneration and bone-grafting will save many limbs from amputation. It is important to know that one may thus excise an entire long bone, leaving behind the epiphyseal lines, and eventually secure a satisfactory restoration through periosteal repair.

Arthroplasty.—A discussion of excisions and resections will deal chiefly, as has already been stated, with the joints. The operation is done for the cure of disease, for the correction of deformity, or for the relief of ankylosis. When the operation is done for disease, the surgeon is confronted by two propositions: First, the disease must be cured; and, second, a movable, serviceable joint should be left at the site of the original articulation. The second proposition, which is presented likewise in the operation for ankylosis, has heretofore been very difficult to meet successfully, since it means the restoration of motion, after most of the normal articular elements have been destroyed or removed. A flexible fibrous union between the ends of the divided bones has been, until recently, the best result that has been possible. This result is more certainly obtained when a subperiosteal resection is made, yet this unfortunately cannot usually be done, and it is not always possible to control either the firmness or the flexibility of such a union even when subperiosteal resection has been accomplished.

Murphy (*Journal of American Medical Association,* May 20th, 1905) has studied this subject with the object of determining the practicability of restoring to the patient a movable functionating joint provided with a synovial membrane. A close analogy has been demonstrated between the evolution of hygromata (acquired sacs lined with endothelium) and the normal embryological development of joints. Joints are primarily formed without a cavity, this feature being developed as a result of a splitting or liquefaction of cartilaginous or connective-tissue elements between the cartilages. Bursæ are formed by the same splitting between fat-capsules on aponeurotic mesoblastic tissue. The fat-capsules coalesce, the fat is absorbed, an increase or hyperplasia takes place in the connective-tissue elements, and a degeneration-liquefaction results in the development of collagen, which subsequently forms the fluid in the cavity of the bursa. The newly developed cavity is lined by cells which appear as flattened endothelial cells and are in fact transformed connective-tissue cells.

These facts have been used for the artificial production of hygroma sacs between bone ends, and it has been shown that such a cavity lined with epithelium can be developed by transplanting between the bones a flap of fat-bearing connective tissue. This method is applicable to the mandibular, hip, shoulder, elbow, knee, and other joints.

The use of the method will necessarily involve a careful study of all pathological conditions presented by the individual case. Ankylosis, for example, may be the result of extracapsular, capsular, or osseous disease; or the joint limitation may be due to the effects of a combination of these lesions. It may therefore be necessary to elongate tendons, resect tendon sheaths, excise scars, or resect the capsule, before undertaking that portion of the operation which concerns the development of the joint.

The principles involved in the operation for ankylosis from adhesive synovitis are given in the following quotation from Dr. Murphy's original article:

"Ankylosis from adhesive synovitis, with fixation of the capsule to the head and neck of the bone, and with the subsequent contraction and cicatrization of the capsule, promises excellent results, if the capsule be completely excised and with it the closely attached ligaments. The head and the neck of the bone should then be surrounded by an aponeurosis or muscle, to prevent the reforming of adhesions. The mere division of the capsule, without its exsection, does not tend to produce a favorable result, as it reunites and so fixes the joint. It must be borne in mind, as a principle in all of these operations, that the joint should permit of free motion and should be independent of severe tension of tendons, capsule, or ligaments. If there be great tension under anæsthesia, there will be tension and pain beyond the ability of the patient to tolerate when the effect of the anæsthesia has subsided. In all of these operations, liberation of the articulation should be to the degree of easy, flail motion, rather than to restricted and limited mobility. In the knee, when the capsule and periarticular tissues are involved in pathological processes, the posterior hamstring tendons and quadriceps and patellar tendons with the crucial ligaments are the only attachments that should be allowed to remain at the time of the operation. All the other ligaments and the capsule should be carefully dissected and removed, and the flaps so arranged that these ligaments will not be reproduced. If the capsular ligaments of the joint alone be divided and a muscle or aponeurosis interposed, the union through this muscular aponeurosis will become so strong and firm before the joint admits of painless passive motion that passive or active motion will be impossible. A point to be remembered in arthroplasty is that the flaps receive nutrition rapidly from the rich vascular supply to the ends of the bone, and that, as flaps are made up principally of fatty and elastic fibrous-tissue elements which have but a slight vascularity, they receive nutriment by osmosis, while a circulation is developing.

"After such an operation the limb should be put up in a position of abduction and hyperextension, as the adductor and flexor muscles are the stronger and are usually the ones that are contracted.

"Failure has resulted from: (1) The insufficient or defective exsection of the synovial membrane, capsule, and ligaments; (2) insufficient interposition of fat and aponeurosis, or of fat and muscle, between the separated bony surfaces; (3) infection; (4) sensitiveness to pain on motion after operation.

"When a bony ankylosis exists, the bones should be separated along the line of union and the bone ends trimmed off sufficiently to give perfectly free flail movement before interposing the flap. Any bony prominences, which might act as a bony stop in the new bony relationship, should be removed."

The following case report by Dr. Murphy will serve best as a description of the operation recommended for the knee joint. This patient had suffered from an ankylosis of both knees following generalized articular trouble, which had kept him in bed for six months.

Case Report: Operation (October 5th, 1901).—The usual preparations were made. Esmarch's constrictor was placed around the thigh and a vertical incision was made over the outer side of the right knee from six inches above to three inches below the joint. The incision was deepened and the capsule of the joint was opened.

The patella was freed, on the outer side, from fibrous adhesions to the femur with scalpel and chisel, and a second vertical incision four inches long was made over the inner side of the joint, which was opened. The patella was then freed on its inner side from the articular surface of the femur. The ligamentum patellæ was not divided. The patella was elevated, the knee flexed, and the adhesions between the tibia and femur were divided to give free motion in the joint. A large flap of fascia lata, with a thin layer of muscle attached, was dissected from the outer surface of the vastus externus, its base being below and anterior. Fig. 208 shows flap dissected down, but attached posteriorly. The flap was then turned over the outer condyle of the femur and drawn through the joint between the two bones by means of heavy catgut sutures, previously passed through its free edge and through the fibrous capsule on the inner side of the joint. The sutures were tied in the inner incision. (Fig. 208.)

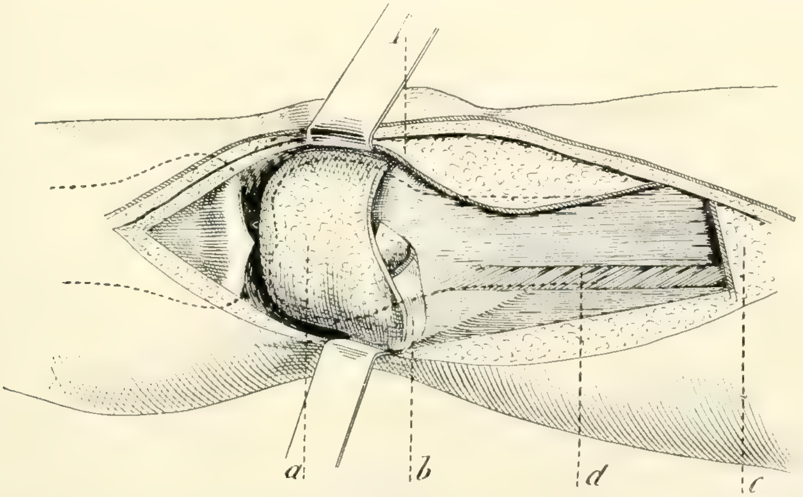


Fig. 208.—Arthroplastic Operation for Ankylosis of Knee. Showing flap carried across knee joint and covering the lower end of the femur. *a*, Flap covering end of the femur; *b*, base of flap; *c*, fat; *f*, retracted fascia.

A small flap of fascia covering the vastus was dissected free in like manner and was placed between the patella and the femur. The flap was secured to the capsule with catgut sutures. The Esmarch bandage was removed and the bleeding points were secured. Subcuticular catgut sutures were used to close skin wounds. A small drain was left in the upper angle of the external wound. Dressings and bandages were applied. The knee was immobilized in full extension by means of a posterior moulded cast of plaster of Paris.

Result.—Convalescence after operation was uneventful and the wounds healed by primary union. The cast was removed permanently after three weeks. The joint was massaged and put through passive motions each day after the first week. On November 13th, the patient was anaesthetized and the knee forcibly flexed and extended several times.

The principles involved in the operation for ankylosis of the hip are given in the following description of Murphy's Case IV.:

This operation for relief of the ankylosis was performed May 2d, 1903. The usual aseptic preparations of the right hip and thigh were made. A U-shaped incision was made, five inches wide with its base upward, beginning four inches above the trochanter and extending downward two inches below it. The trochanter was exactly in the centre of the U. The incision was through the skin, superficial fat, and fascia lata, and these tissues were dissected upward as one flap. A long curved needle, threaded with heavy silk, was passed around the base of the trochanter beneath the muscles attached to it, and by means of this carrier a chain saw was brought into position. The trochanter was then sawn off and retracted upward. The capsule of the joint was next incised and separated from the ilium all the way around. The attachment of the gluteus maximus was not disturbed. The bone was examined, and the neck of the femur was found to be continuous with the margin of the acetabulum by firm bony union. The formation of a new head for the femur and a new acetabular cavity was the next step in the operation and was accomplished in the following manner: The bony tissue filling the acetabulum was chiselled free from the latter by following around its margin (the line of junction with the neck) with a carpenter's curved chisel one inch and a half in diameter. The chisel each time was driven in obliquely toward the fossa acetabuli, the object of this being to make the new femoral head as nearly spherical as possible. When the chiselling process was completed, the new head was entirely separated from the sides of the acetabulum and was attached only at the bottom by a narrow bridge of bone. The bridge was fractured by forcible abduction of the limb, after which the head was dislocated from the cavity by external rotation of the thigh. The shape and contour were almost exactly those of a normal femoral head, except for a few sharp, bony projections which were removed by means of a bone-cutting forceps. Examination of the acetabulum showed that the opening at the bottom, through which the necrotic bone had been removed at an earlier operation, was entirely closed by a deposit of new bone. A curette was used to smooth off the irregularities produced by the chisel and to enlarge the cavity. The fascia lata which formed a part of the original U-shaped flap was now dissected away from the subcutaneous fatty tissue down to its base, where the vessels entered to supply it with blood. The flap of fascia was then drawn down under the head of the femur and carefully fitted into the acetabular cavity to form a complete lining for it. The under surface of the flap, one-half inch from the edge, was sutured to the joint capsule around the acetabular margin with interrupted catgut sutures to secure it and to prevent its subsequent displacement. The new socket being in readiness, the head of the femur was returned to its normal position by extension and adduction of the thigh. It was found to fit accurately and it could not be dislocated by any of the ordinary motions of moderate degree. The free border of the fascial flap, which projected from the margin of the acetabulum, was now sutured with interrupted catgut sutures to the periosteum, and the capsule was attached to the neck of the femur. The flap was amply large, so that it completely covered the head and came well up upon the neck without tension. (I consider this a very important point; the entire articular surfaces of the head must be covered by fascia if we are to expect a good functional result, and the same applies to other joints.) The great trochanter was brought down to its normal position and accurately secured with two aluminum-bronze wire sutures. The skin flap was replaced and sutured with horsehair. No drainage was used. Because of the contraction of the flexors and adductors of the thigh, extension and abduction were limited and were accomplished only by the use of considerable force. The contraction was overcome by forcibly stretching the muscles, using the thigh as a lever and at the same time exerting with the edge of the hand strong pressure, combined with a sawing motion, over them near their point of origin, after the Lorenz method. The sartorius was divided with the scalpel close to its attachment to the anterior superior spine of the ilium. To retain the limb immobilized until the firm union of the parts had been secured, a plaster cast was applied, including the pelvis and entire limb in full extension and abduction.

One year later, this patient was able to walk without crutch or cane, the motion in the joint was free and of normal extent and unaccompanied by pain.

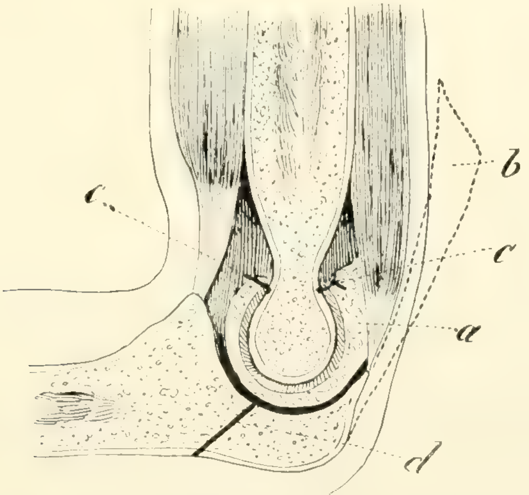


FIG. 209.—Arthroplastic Operation on the Elbow Joint. *a*, Fat-bearing fascial flap; *b*, flap before it is displaced into joint; *c*, *c*, flap sutured to periosteum; *d*, saw-line through olecranon.

The operation on the elbow is done through a posterior median incision six inches long. The fascial flap is removed from the posterior surface of the triceps muscle. (Fig. 209.)

Dr. Murphy has stated in a recent communication that this method of operating has not been materially changed during the past two years. An increased experience has emphasized the importance, however, of including a liberal layer of fat in the flap, of extensively excising the ligaments, and of establishing free motion at the time of operation.

The development of this method for the restoration of a true joint after excision of the joint structures marks an advancement in the excision of diseased joints, the importance of which can scarcely be estimated. The principles involved must henceforth be taken into consideration in all joint operations where ankylosis or possible restriction of motion may result from disease or operation.

SPECIAL EXCISIONS.

Excision of the Superior Maxilla.—Excision of the upper jaw will be required for a number of conditions, and may be partial, total, or temporary.

The development of new growths will furnish the most frequent indication for the operation. Fibromata, sarcomata, carcinomata, enchondromata, dentigerous cysts, osteomata, and adenomata are the forms of tumors which are to be considered. Necrosis from suppurative disease may demand a partial resection. Tumors in the naso-pharynx or at the base of the skull may require temporary resection of the jaw for their exposure. It will not be possible to discuss in this place the differential diagnosis of the above-mentioned tumors; but it is a matter of very evident importance to decide definitely upon the seat of origin, the extent of development, and the nature of the growth before deciding upon excision. A malignant growth may develop entirely behind the antrum and push its way forward through this cavity, and in many instances the disease will be found entirely inoperable at the time when the patient first presents himself with a tumor of the upper jaw. The writer has recently seen a case which seemed to present conditions favorable to excision; yet a history of polyp, removed some months previously from the posterior portion of the nasal passage on this side, and the presence of an exophthalmos, introduced a suspicion of a deep-seated tumor. An exploratory opening was therefore made through the anterior wall of the antrum, and there was revealed a large cavity which extended backward to the base of the skull. The condition was clearly inoperable, and the patient was saved a very extensive operation. (Consult also the article on Diseases of the Jaws, Vol. V.)

The chief obstacles which are encountered in any one of the operations about to be described, are furnished by the high degree of vascularity of the region and the difficulty in administering an anæsthetic.

The question of hemorrhage calls for special consideration, both because of the loss of blood which may occur at the time of operation, and because of the aspiration of blood into the lungs, which has always been a most dreaded complication in this operation. Preliminary tracheotomy and tamponing of the pharynx will insure good anæsthesia and will effectually prevent aspiration of blood into the lungs, but this operation possesses definite dangers of its own and is not to be recommended. The dependent position of the head, according to Rose, has also been used as a means of preventing the aspiration of blood; but this position materially increases the flow of blood to the region and renders the field of operation rather inaccessible, and is therefore rarely used.

Preliminary ligation of the external carotid artery has become the method of choice in controlling hemorrhage. It is not a dangerous operation and it will usually control the blood supply satisfactorily. It may be stated, further, that the operation of excision of the upper jaw for malignant disease cannot be considered to be complete without a thorough dissection of the lymphatics of the submaxillary triangle, and the external carotid can be easily ligated as one step in this operation. Temporary compression of the carotid arteries, as has been suggested by Crile, will undoubtedly supersede ligation in some cases, since it makes possible the performance of a bloodless operation without permanent damage to the arterial supply.

Aspiration pneumonia is very greatly influenced by the nature of the anæsthesia. A profound anæsthesia is to be avoided, since even with the greatest care some blood is almost certain to find its way into the pharynx, and then aspiration will take place. The anæsthesia of choice for the operation will be one that will, in so far as possible, prevent pain, yet will at the same time preserve the reflexes of the respiratory passages. The best results will be obtained by a morphine-chloroform or morphine-ether narcosis. A hypodermic injection of one-fourth or even one-half a grain of morphine is given one-half hour before operation. The patient is then fully anæsthetized with chloroform or with ether at the time of operation, the mask is removed when all is ready for the first incision, and the operation is completed without reapplying the mask. In this way the patient will be entirely anæsthetized at the time of incising the skin and during the dissection of the skin flap, but for the remainder of the operation he will be in a semi-conscious condition, and the reflexes will be sufficiently active to cause him promptly to expectorate any blood that may find its way into the pharynx. The patient will furthermore be able to lend valuable aid by changing his position at the suggestion of the surgeon. He suffers very little pain during the operation, but may object somewhat when the sutures are applied.

A semi-reclining position will greatly aid the patient in keeping his throat clear.

The Operation.—Before undertaking either a partial or a total resection of the jaw, it is indispensable that the anatomical elements involved should be given careful attention. Lines of incision should be used which will give scars that are not only inconspicuous, but that will not interfere with the play of the features. The course and the distribution of the facial nerve should receive full consideration. Stenson's duct must be avoided, as it passes from the parotid gland to empty into the mouth opposite the second molar tooth. The course of the duct will be indicated by a line drawn from the lobe of the ear to a point midway between the ala of the nose and the border of the upper lip. The anatomy of the bone can be reviewed at a glance, by the aid of a dry skull, and the lines of bone section necessary for its removal are sufficiently indicated in Fig. 210.

A great variety of incisions have been recommended for exposing the upper jaw for excision; but there is, in reality, only one method of performing the resection proper. Lizar and Velpeau made a curved incision from the angle of the mouth upward and outward to the malar process and then over to the angle of the orbit. (*aa'*, Fig. 211.) Liston made a similar, but straight, incision, which was extended when necessary along the zygoma. (*cc'*, Fig. 211.) These incisions are open to the very serious objection that they expose both Stenson's duct and the facial nerve to injury, and they leave considerable disfigurement.

The incision of Fergusson (*bb'*, Fig. 211) possesses many advantages over all other incisions and is almost without exception the incision recommended by surgeons. After the posterior nares have been plugged and the arteries of the lip have been secured on both sides by the application of medium-sized serre-fine clips, an incision is made through the median line of the upper lip, thence close around the ala of the nose, up along the side of this organ to the inner canthus, and outward along the lower border of the orbit as far as the malar prominence. A brisk hemorrhage will follow, but this can be easily controlled by pressure; and, if a gauze dressing has been placed inside the lips before the incision was begun, no blood will get into the mouth. The flap, thus outlined, is rapidly dissected outward close to the bone, and all hemorrhage may then easily be controlled. The ala of the nose having been separated

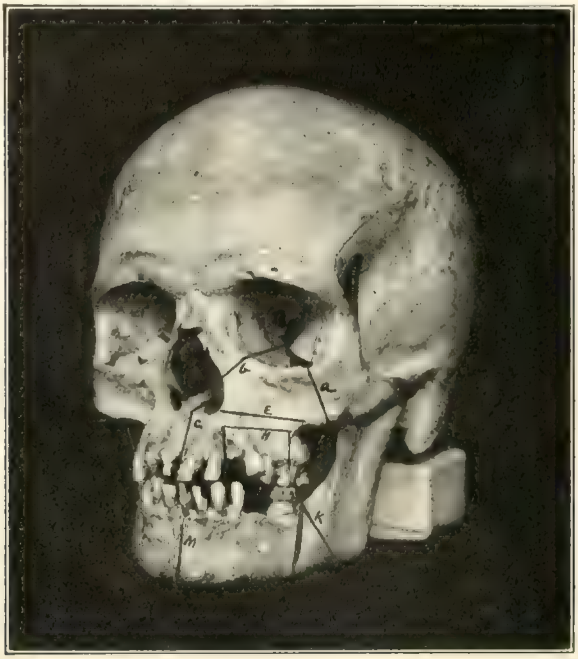


FIG. 210.—Excision of the Upper and Lower Jaws. *a*, *b*, *c*, Lines of bone section in total excision of the upper jaw; *e*, *c*, lines of bone section in partial excision of the upper jaw; *h*, excision of the alveolar border; *k*, Esmarch's wedge-shaped resection of the lower jaw for ankylosis; *m*, saw line in resection of lower jaw. (Original.)

from the bone, and the periosteum of the orbit having been elevated, it will be found that the bony surface of the upper jaw is thoroughly exposed.

The malar process of the superior maxilla is now divided with bone-forceps or by a saw, just in front of the origin of the masseter muscle, the eye being protected by the index finger of the operator's left hand placed on the margin of the orbit. (Figs. 210 and 212.) This bone section is on a line with the spheno-maxillary fissure. The thin floor of the orbit is next divided with a scalpel from the inner end of the spheno-maxillary fissure forward to the nasal process, and this process is divided with bone-forceps. The attention is now directed to the interior of the mouth, where the mucous membrane is divided, first transversely along the line of junction between the hard and soft palates, then along the median line. The mucous membrane of the nose is likewise divided by a longitudinal incision made alongside the septum. The hard palate is then divided antero-posteriorly with a metacarpal saw along the line of this nasal incision. All bony connections have now been divided, and the body of the jaw is seized with lion-jaw forceps and by a combined rocking and twisting motion the bone is very rapidly torn away from all posterior connections. A very brisk hemorrhage will follow immediately, and a serious loss of blood will occur unless an assistant is ready to plug the cavity at once with a large gauze dressing. This plugging of the cavity should be very firm and should be supplemented by continued hand pressure. After a few minutes the packing is gradually removed in layers, and bleeding points are secured as they are uncovered.

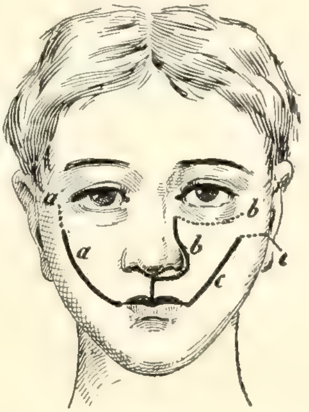


FIG. 211.—Excision of the Upper Jaw. (After Bryant.) *aa'*, The Lizar and Velpeau incision; *bb'*, the Fergusson incision; *cc'*, Liston's incision.

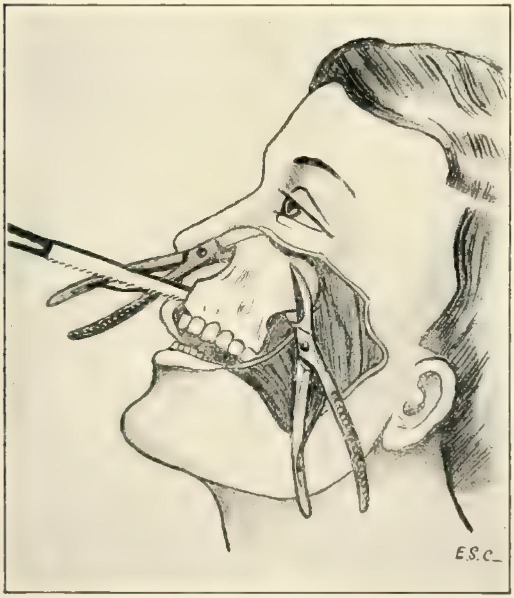


FIG. 212.—Excision of the Superior Maxilla. (After Bryant.) The soft tissues have been reflected in a flap made by the Fergusson incision, and the bony connections are about to be divided.

In some instances it may be deemed wise to leave the pterygoid process, together with its attached muscles, undisturbed. When it is not to be removed, the flap is forcibly pulled backward, the soft tissues are separated from without, as far back as the pterygoid, and the bony process is chiselled off from without.

Should any cancerous tissue remain behind after the jaw has been excised, it should be removed by means of the rongeur forceps, by sharp dissection, or, as has been suggested by Jacobson, by the application of a zinc-chloride paste made up with equal parts of flour.

The wound is now completely closed by suture, with or without drainage. The after-treatment of the wound is greatly facilitated, in those cases in which the mucous membrane over the hard palate is not involved, by making the incision just inside the alveolar border and separating it from the palate as far as the middle line. This will make it possible to suture the mucous membrane of the mouth to the line of incision in the inner side of the cheek, and the wound cavity can be excluded from the mouth.

The wound cavity, however, is almost certain to become infected and foul, and provision must be made for free irrigation. The after-treatment should be conducted with the patient in the sitting posture, to facilitate drainage of the cavity; and the latter should be irrigated twice daily with normal salt solution or with a solution of potassium permanganate. Mouth-washes should be used freely in the interval. The most efficient irrigation will be accomplished by passing a soft-rubber catheter as far as to the apex of the cavity and allowing a liberal quantity of the solution to flow through it from a fountain syringe, as the patient bends over a basin.

For a few days the patient's diet should be limited to fluids, and these should be taken through a soft tube. Healing of the face wound usually takes place very promptly and without scarring; the disturbed sensation is slowly regained, and the disfigurement is not great. Speech will be faulty because of the hole in the hard palate, but this can be remedied by wearing a plate over the opening. Furthermore, a skilled dentist can improve very greatly the disfigurement which results from the sinking in of the cheek. When the operation has been done for malignant disease, plates, which may cause continued irritation or pressure, should not be kept applied for any considerable period of time.

The primary results from the operation are usually good, since death rarely results from the operation alone. The ultimate results as to cure, deformity, and speech will be good in the non-malignant cases; but this cannot be said regarding operations performed for the eradication of a sarcoma or a carcinoma. The disease has usually extended so far, before the patient applies for operative relief, and the probability that some extensions of the disease will be left behind is so great, that recurrence is extremely likely to occur. When, therefore, it is evident, upon examination, that the disease has extended beyond the limits of the maxilla, the operation should not be undertaken.

Subperiosteal Excision.—When excision is done for non-malignant conditions, the periosteum should be left. So far as its essential principles are concerned, this operation does not differ greatly from that already described. The Fergusson incision (or the perpendicular median portion alone of this incision) is again the incision of choice; but Ollier's incision, beginning over the malar bone and extending to the upper lip, one-third of an inch from the angle of the mouth, is preferred by some operators. The skin flap is very carefully separated from the external surface of the bone by a periosteal elevator. The mucous membrane on the outer suface of the alveolar border is then divided down to the bone from the incisor or canine tooth, in front, to the last molar behind. This incision is continued around the last molar and back along the inner surface of the alveolar border to a point directly opposite the point of beginning. A supplementary incision following the course of the premaxillary suture is continued to the median line of the hard palate. The periosteum is now separated from all surfaces of the bone, and the connections between the hard and soft palates are divided. The remaining steps of the operation are identical with those already described in the non-subperiosteal operation. The wound left by such an operation can be more easily managed and the results are in every way very much better, since a considerable regeneration of bone occurs, and, even when this fails to take place, a firm connective-tissue support is given to the tissues.

Partial Excision.—A partial excision of the upper jaw will be demanded for the relief of limited disease of the bone. This operation will be of necessity atypical in its nature and in every instance will be designed to meet the requirements of the individual case. The bone may be exposed and excised through incisions made wholly within the mouth, or the same external excisions that have been described above may be used. The amount of bone removed will vary greatly. A transverse saw line may be used, just below the border of the orbit, or below the infraorbital foramen (*e*, Fig. 210), or it may be necessary to remove the outer wall of the antrum alone, or the alveolar border of the bone alone. (*H*, Fig. 210.) The excision may be by the subperiosteal or by the non-subperiosteal method, the choice depending upon the condition for which the operation is performed. The bone can be very advantageously removed in partial excision with a rongeur forceps or with chisel and mallet. The mechanical dentist can do much to correct deformity and defect in speech after an operation of this type. He will be greatly assisted in this work if the canine tooth has been preserved, since this tooth not only gives form to the face from the front, but it provides the best point of attachment for mechanical devices.

The simultaneous excision of both halves of the upper jaw is performed by an incision similar to that recommended by Velpeau, and running from the angle of the mouth to the middle of the malar bone on each side. The entire face is then dissected upward as far as the orbit in one flap, both nasal processes are divided as in the single operation, the hard palate is separated from the soft palate, and both jaws are removed. Should it be deemed wise to remove each half separately, the hard palate should be divided in the median line as in the operation for the excision of one side only.

Dieffenbach makes a vertical median incision which extends along the ridge of the nose and is continued downward through the upper lip. This incision is supplemented by lateral transverse incisions made from the upper end of this incision and extending outward to a point one-half inch below the middle of each orbit.

This operation will necessarily result in much deformity, but the patients usually recover satisfactorily. Fortunately, the operation is rarely indicated.

Osteoplastic Resection of the Upper Jaw.—This operation is sometimes performed for the exposure of tumors at the base of the skull. This may be accomplished either from the face or through the mouth, but it should be remembered that a surgeon who is expert in nose and throat operations can usually manage the operable tumors through the nose and mouth.

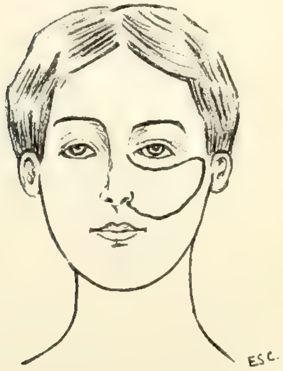


FIG. 213.—Langenbeck's Incision for Osteoplastic Resection of the Upper Jaw.

Langenbeck has designed an operation by the facial route in which the incision begins at the inner angle of the eye and extends along the lower border of the orbit to the malar bone, where it makes a broad loop and returns, as indicated in Fig. 213, to the ala of the nose. This incision is continued down to the bone. The masseter muscle is divided from the lower border of the malar bone, the soft tissues are elevated from the outer and posterior surface of the maxilla, and a narrow-bladed saw is forced through into the pharynx, where it is intercepted by the index finger of the left hand passed in through the mouth. The soft parts are retracted and the upper jaw is now sawed through horizontally just above the alveolar border. (Fig. 214.) The soft parts are still further dissected in the malar region and the zygomatic arch is sawed through in the middle. The frontal process of the malar bone is now divided as far as to the spheno-maxillary fissure, and the floor of the orbit is divided as far as the nasal process. Care should be taken not to injure the nasal duct. All bony attachments are now divided, and the skin and bone flap can be pried up and turned inward to the median line. The tumor is then removed and the osteoplastic flap is turned back into place. O. Weber modifies the external incision in this operation by placing the base of the flap in the malar region and reflecting the flap outward. In this way the facial nerve is less likely to be injured.

These operations are very bloody, and, as has already been stated, the expert can usually accomplish the same result through the nose and mouth; as a matter of fact, the operation is not generally employed.

Excision of the Lower Jaw.—Excision of the lower jaw will be required for necrosis, which has resulted either from infection or from the action of phosphorus, or for the removal of a tumor. Central sarcoma is the most common type of new growth that occurs in this bone, and it presents favorable conditions for operation, since it grows slowly, does not infiltrate the surrounding tissues, and does not usually cause lymphatic involvement. Particular attention is called to the necessity of making an accurate diagnosis before deciding upon an excision. The writer had this point very definitely brought to mind by a case of dentigerous cyst which had passed through the hands of more than one surgeon as a case of sarcoma. The diagnosis had even been confirmed by a microscopic examination of adjacent granulation tissue which revealed giant cells (irritation giant cells); yet an incision into the well-marked central tumor of the jaw revealed a typical dentigerous cyst. Subsequent microscopic examination of the thickened tissue which had been removed with the cyst showed no evidence of sarcoma; and the patient has remained perfectly well since this operation, which was performed several years ago.

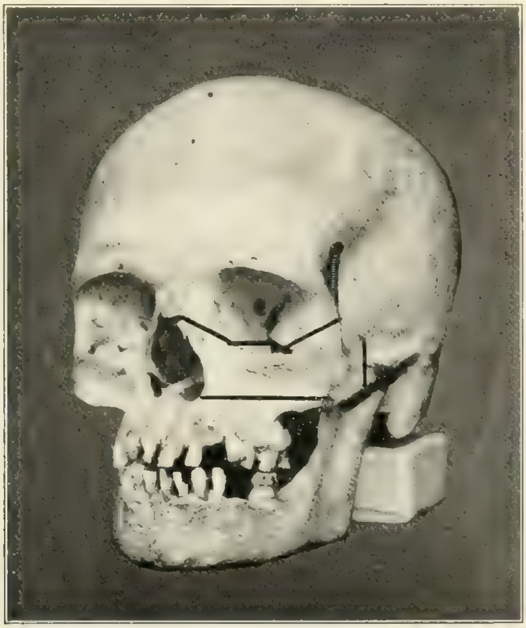


FIG. 214.—Lines of Bone Section in Osteoplastic Resection of the Upper Jaw. (Original.)

The dangers that have already been mentioned in describing the operation of excision of the upper jaw will be frequently encountered in excision of the lower jaw. The aspiration of blood is perhaps less likely to occur, but should receive due consideration. The rules with regard to the administration of the anæsthetic and the position of the patient should be the same in this operation as in that for excision of the upper jaw.

When the continuity of the arch of the jaw is not interrupted, we speak of the operation as a *partial resection;* when a greater or less extent of the arch of the jaw is removed, it is spoken of as a *complete resection;* or the resection is said to be *temporary,* when the bone is divided for the purpose of exposing deeper structures, and then is sutured back in place. Whenever possible, the periosteum should be preserved—since a certain amount of bone will be reproduced; and, even though no bone be formed, this membrane serves as the basis for a firm connective-tissue body, which will give attachment to the muscles and serve as a support upon which prosthetic apparatus may be fitted. It is, of course, impossible to preserve the periosteum in malignant disease.

ANATOMICAL CONSIDERATIONS.—There are many anatomical points to be remembered in the course of this operation. For example, the facial nerve is always in danger when the incision extends past the angle of the jaw. Also, the lingual nerve lies very close to the inner surface of the ramus, while the internal maxillary, inferior dental, and external carotid arteries are in such close relationship to this structure that they are liable to be injured. The muscles of mastication should be preserved whenever possible, and great care should be taken to hold the tongue strongly forward whenever it becomes necessary to divide the anterior attachments of the genio-hyo-glossus muscles, since they have much to do with maintaining the tongue in position. Should this point be neglected, the patient might quickly suffocate from the tongue falling back over the larynx.

PARTIAL RESECTION.—Partial resection involves, as a rule, only the alveolar process, but may extend well down into the body of the jaw in the case of necrosis or a dentigerous cyst. This operation is usually performed entirely within the oral cavity, and it is unnecessary to divide the angle of the mouth even when the disease is located well back toward the ramus, since the mouth can be sufficiently retracted. When the operation is performed for non-malignant disease, the periosteum is carefully elevated over the diseased area and the bone is cut away with strong bone-forceps. The cavity left is packed firmly with plain gauze for twenty-four hours, then is treated by frequent irrigation with some bland mouth-wash. In phosphorus necrosis, it may be possible to excise the sequestrum through an external incision, made just below the lower border of the jaw, without interfering with the continuity of the involucrum, and without opening into the cavity of the mouth.

COMPLETE RESECTION.—Complete resection of a portion of the bone, or the resection of an entire half of the bone, is not a difficult operation. A complete solid arch is necessary for the performance of function. The greatest difficulty, therefore, will arise from the prosthetic viewpoint.

The incisions used will be made either wholly within the mouth or wholly on the external surface, or it may be found necessary to employ both kinds of incisions. The central portion of the jaw or a limited segment of the lateral portion may be removed by internal incisions alone; while the ramus or the portion of the bone behind the teeth can be removed subperiosteally through an external incision, without opening into the cavity of the mouth. Complete removal of the lateral half of the lower jaw will require both a median and an external lateral incision along the border of the jaw (*b*, Fig. 215). Excision for phosphorus necrosis is usually an easy operation, and can be done either from within or from without. When the teeth are hopelessly lost, the operation should be done from within; when there seems a chance to preserve the teeth in the newly formed bone they should be left undisturbed and the sequestrum should be removed from below through an external incision.

Excision of the central portion of the jaw, even when the part to be removed extends back as far as the angle, can be most satisfactorily accomplished through a median incision which divides the lip and extends downward as far as the hyoid bone. This incision is easy to make, leaves very slight disfigurement, and eliminates largely the dangers of injury to the muscles and nerves of deglutition. After this incision has been made, a heavy silk suture should be passed through the tongue well behind the tip, and its two ends tied together for use as a tractor. This will prevent the tongue from falling backward over the glottis when the genio-hyo-glossus muscles are divided. A tooth is now drawn at the site of the proposed bone section, and the jaw is divided with a Gigli saw. Then, after the sawed end has been drawn forcibly outward, the periosteum is carefully separated from the bone until the site of the second bone section has been reached.

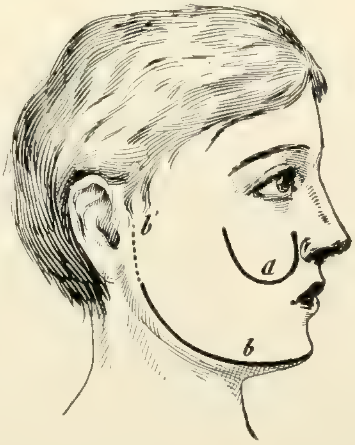


FIG. 215.—Excision of the Upper and Lower Jaws. *a*, Langenbeck's incision for excision of the upper jaw; *b*, incision for removal of lower jaw.

When the central portion of the bone alone is to be resected, a curved incision is made inside the mouth along the line of the fold of the buccal mucous membrane, the soft tissues are dissected away from the outer surface of the bone, and all of the soft parts of the chin are pushed back beneath the tip of the bone. After the desired amount of bone has been removed by either one of the foregoing methods, hemorrhage is carefully arrested, an interdental splint (which has been previously constructed) is fixed to the sawed ends of the bone, and the periosteum is sutured over this mould. It is very important that the two ends of the bone should be kept properly separated during healing. The presence of a moulded interdental splint will influence the newly forming jaw to develop in a proper shape. Unless this precaution is taken there will be a tendency for the two ends of the bone to fall more and more together, thus interfering in many ways with the comfort and appearance of the patient. Chewing will be interfered with by a lack of perfect approximation of the biting surfaces, swallowing and speaking may be imperfect, there will be an annoying flow of saliva, the chin will become increasingly disfigured, the tongue will show a tendency to fall backward, and the mouth will become narrower and narrower until the movements of the tongue are very seriously impaired, more especially if the portion of bone removed be of considerable size. Carefully constructed interdental splints; division of the bone, when possible, just external to the insertion of the genio-hyo-glossus muscles; and resuture of these muscle insertions, when they have been divided, to as solid a point as can be found, will do much to prevent the distressing symptoms to which I have just referred.

Excision of the lateral half of the lower jaw will be necessary when the disease involves the angle and the ascending ramus of the jaw. For this operation an incision is made from the median line in front, beneath the lower border of the jaw, to the angle, then upward along the posterior border of the ramus, as far as the lobe of the ear (*b*, Fig. 215). Great care should be taken not to injure the facial nerve. This incision may be supplemented by a perpendicular median incision in front, while the posterior portion of the incision may be very wisely utilized for ligation of the external carotid artery above the thyroid or above the lingual artery. The bone is first exposed in front and divided just external to the point of insertion of the genio-hyo-glossus. (Fig. 216.) The end of the portion to be removed is now pulled strongly outward and the connections of the bone are carefully separated back to the coronoid process. This process, together with the insertion of the temporal muscle, is now clipped off with bone-forceps, and the neck of the bone is cleared by blunt dissection, great care being taken to protect the internal maxillary artery and the lingual nerve. The head of the bone is then removed by twisting it forcibly away from its connections. Sharp instruments should be avoided in this disarticulation. Hemorrhage will be greatly lessened if the inferior dental artery is caught before it is divided. After all hemorrhage has been arrested, the flap is sutured back in place, and drainage is placed at the former position of the angle of the jaw.

As has already been stated, this operation is not attended by great technical difficulties; yet the ultimate result will not be satisfactory unless the resected portion of the jaw is immediately replaced by artificial means. Muscular and cicatricial contraction causes the stumps of the jaws to be drawn inward in a surprisingly short time, and when the deformity has once occurred it will be practically impossible to overcome it. Some device must therefore be applied immediately in order to prevent the evil.

Martin constructs an artificial jaw from gutta percha, which can be accurately fashioned at the time of operation to fit into the defect, and which is screwed or nailed to the stumps of the bone by lateral metal plates. This provisional splint is left in place during the course of wound-healing, and serves to support both the bony and the soft parts. When healing is complete a permanent plate fitted with teeth is applied.

Other surgeons have used metal plates in the same way. These plates should be sufficiently large and so shaped as to give proper support to the soft parts or even to stretch them, and they can be either wired or screwed to the bone ends. Aluminum has been used with much satisfaction by Partsch and Stoppany for this purpose. A metal splint can be easily kept clean, and in from three to four weeks it can be replaced by a permanent plate. Carl Beck has reported a case in which paraffin was used to correct severe deformity after resection of the entire lower jaw, no provision having been made, after the primary operation, for the prevention of deformity and loss of function. The paraffin was injected along the entire length of the former position of the jaw, and an excellent cosmetic and functional result was obtained.

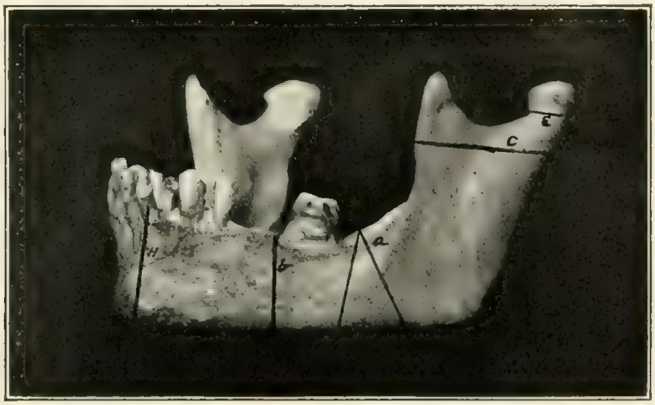


Fig. 216.—Excision of the Lower Jaw. *a*, *c*, and *e*. Lines of bone section in ankylosis of the lower jaw. (Original.)

Osteoplastic Resection of the Lower Jaw.—This operation is performed for the free exposure and operative treatment of lesions in the floor of the mouth, at the root of the tongue, or in the fauces. For the exposure of lesions anterior to the fauces a median incision through the lip and bone is used. When the disease affects the fauces or the pharynx, a better exposure will be obtained by dividing the bone just in front of the ascending ramus of the jaw. Langenbeck recommends an incision that is carried perpendicularly downward from the angle of the mouth, while Kocher prefers an incision which has been recommended above for excision of the posterior portion of the lower jaw, and which is made parallel to and underneath the border of the jaw. Inasmuch as the posterior fragment will invariably show a tendency to become displaced upward and inward, after division at this point, the bone is sawed along a line extending from above obliquely downward and forward, and from without inward and backward. In osteoplastic resection the drill holes, for resuture of the bone, should be made before the bone is sawed through.

Resection of the Temporo-maxillary Articulation for the Relief of Fixation of the Lower Jaw.—Immobility of the lower jaw develops as a result of cicatricial contraction of the soft parts, as a result of articular ankylosis, or from unreduced dislocation.

Cicatricial contraction of the tissues of the cheek will follow sloughing set up by cancrum oris, burns, scarlet fever, measles, typhus, mercurial stomatitis, alveolar abscess, and suppurative disease of the malar bone. Firm fibrous bands form within the mouth, and the lower jaw is firmly bound to the upper, producing complete immobility without disease of the articulation. The same disease may, however, produce a simultaneous arthritis with ankylosis, or a suppurative inflammation may develop primarily in this articulation, and the only cause of immobility in the lower jaw may be an ankylosis of one or both temporo-maxillary articulations. The operation required for the relief of immobility will therefore depend upon the nature of the obstruction. When the fixation is caused by cicatrical tissue, it will do no good to divide the cicatricial bands, since they will promptly re-form; and plastic operations undertaken for the cure of such bands are so frequently unsuccessful that surgeons have uniformly decided that the new joint must be made in front of the limiting cicatricial tissue. This conclusion has been very largely modified by the suggestion of Helferich, Mikulicz, and Murphy, to interpose muscle or fascia between the divided bone ends. This arthroplastic procedure is not sufficient in itself, however, to secure the desired result; the limiting cicatricial tissue should be sufficiently excised to give free motion, and a flap of skin from the neck should be transplanted into the defect. At the same time it must be understood that the nature and the extent of the lesion will differ so greatly in these cases that the operation must be planned to meet the indications of the individual case. This type of immobility of the lower jaw has its origin in the period of youth, and the primary disease will usually be found to have influenced the development of the entire lower jaw to such a degree that it preserves its youthful size and shape in adult life. This increases greatly the difficulties of obtaining a satisfactory result. When the fixation is the result of ankylosis alone, an arthroplastic operation will give an excellent result.

Operation for the Establishment of a Joint Anterior to Cicatricial Bands.—The incision will vary with the proposed location of the new joint. This may be located almost as far forward as the mental foramen or as far back as the coronoid process. The modern requirements of tissue interposition demand a liberal incision below the border of the jaw—one which will not only expose the bone, but will likewise give a sufficient fascial flap. The new joint should, of course, be made as far back as is possible.

The incision is carried down to the bone at the site of the section, the periosteum is elevated on both sides, and a wedge-shaped piece, the base of the wedge being below, is removed with a saw or a rongeur. When enough bone has been removed to insure perfect mobility, a flap of fat-bearing fascia from the neck, or a muscle flap from the masseter or the temporal muscle, is carefully sutured in place between the divided ends, and the wound is closed. As has already been stated, the site of this bone section will be in the body of the bone in front of the masseter, as has been suggested by Esmarch (*a*, Fig. 216); or the wedge may be made to include the angle of the jaw, as has been suggested by Swain; or the site of section may be selected even higher up.

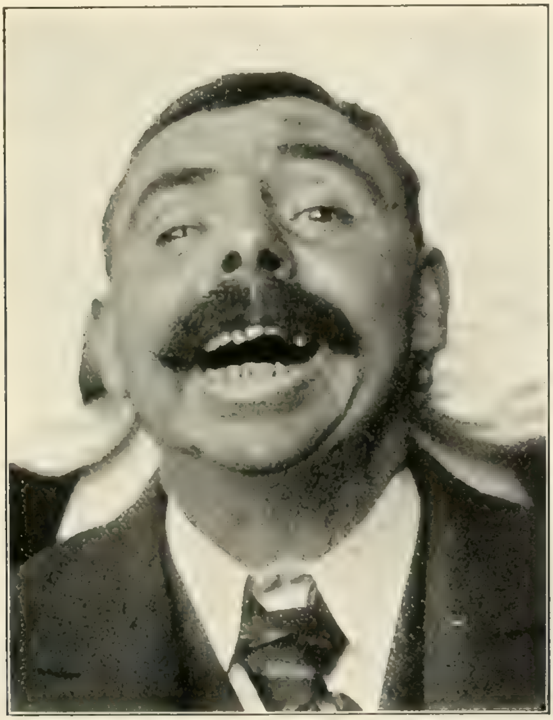


FIG. 217.—Double Resection of Temporo-maxillary Articulation. Four months after operation, the space between the incisor teeth measures three-fourths of an inch in width. (Original.)

After such an operation the very greatest patience and persistence will have to be practised by both surgeon and patient in keeping up systematic passive and active motion in the new joint.

EXCISION OF THE TEMPORO-MAXILLARY ARTICULATION.—This operation will be demanded in those cases in which the fixity of the jaw is due to ankylosis of this joint. A careful history of the patient should be taken in order to determine which articulation is at fault, since total immobility may result from ankylosis in only one of the two joints. The patient whose photograph appears in Fig. 217 gave no history whatever of trouble in either articulation, and could remember only that he had been in this condition since childhood. The ankylosis seemed double, however, and, inasmuch as no member of his family was present to give an accurate history, a double excision was deemed necessary. Unfortunately, the fairly normal articulation was operated upon first and only a very slight improvement in motion was thereby secured. Free motion was obtained only after a firm bony ankylosis had been liberated on the opposite side. The patient's mother came to visit him after the operation, and, after rather rigid questioning, she remembered that the ankylosed side had been much swollen and very painful and that pus had been discharged from the ear after an attack of scarlet fever when he was seven years old.

The details of the operation may be described as follows: The articulation is exposed by a transverse incision made along the lower border of the zygomatic arch and by a second vertical incision. The transverse incision is very carefully extended down to the border of the bone, but the vertical incision is made through the skin alone. The soft tissues, including the parotid gland and facial nerve, are now drawn downward, and the articulation is exposed by blunt dissection. The neck of the bone is then divided with a chisel (Fig. 216), and the condyle is either displaced with a periosteal elevator, or, in the case of a bony ankylosis, it is removed with a gouge. After a sufficient amount of bone has been removed to give entire freedom of motion, Helferich advises the careful introduction and suturing of a flap of the temporal muscle between the glenoid cavity and the cut end of the bone. Kusnagow uses a flap from the masseter. Murphy advocated the use of the temporal fascia or a flap composed partly of fascia and partly of muscle.

The after-treatment of cases of this sort does not differ from that already described.

Resection of the head of the bone for unreduced dislocation should be conducted in a manner entirely similar to that described for ankylosis.

Excision of the Shoulder Joint.—The anatomical arrangement of the shoulder girdle provides for a range and character of motion which are not found elsewhere in the body. The supplementary motion given to the shoulder by the free mobility of the scapula aids so materially in counteracting limitations of motion or even ankylosis of the shoulder joint, that conservative operative treatment of suppurative arthritis will usually give results superior to those obtained by excision; and, as a matter of fact, excision of this joint is rarely done. A second reason for the infrequent performance of excision of the shoulder is the fact that tuberculosis of this joint is rare.

Inasmuch as excellent supplementary motion can thus be gained in a damaged joint, the demands upon the operation of excision become very exacting; it must give assurance that by means of it something more than fair motion will be secured. In the anatomical arrangement, abduction, adduction, flexion, extension, and rotation, or combinations of these movements, are provided by muscles many of which have their points of insertion in the immediate region of the joint. This, together with the fact that resection of the shoulder usually necessitates a division of the bone in the surgical neck and a detachment of all muscle insertions, presents plainly the difficulty that will be encountered in obtaining great range of motion after excision. (Fig. 218.) Such an operation will mean, for instance, a division of the connections of the supraspinatus, the teres minor, and the subscapularis; and the movements of rotation, which are dependent upon these muscles, will be permanently lost. A subperiosteal resection will, it is true, reduce greatly this loss of motion; and, in many instances, regeneration will take place to a degree that will restore almost normal rotation; nevertheless, such a complete result must not be confidently expected. The same is to be said regarding division of the deltoid.

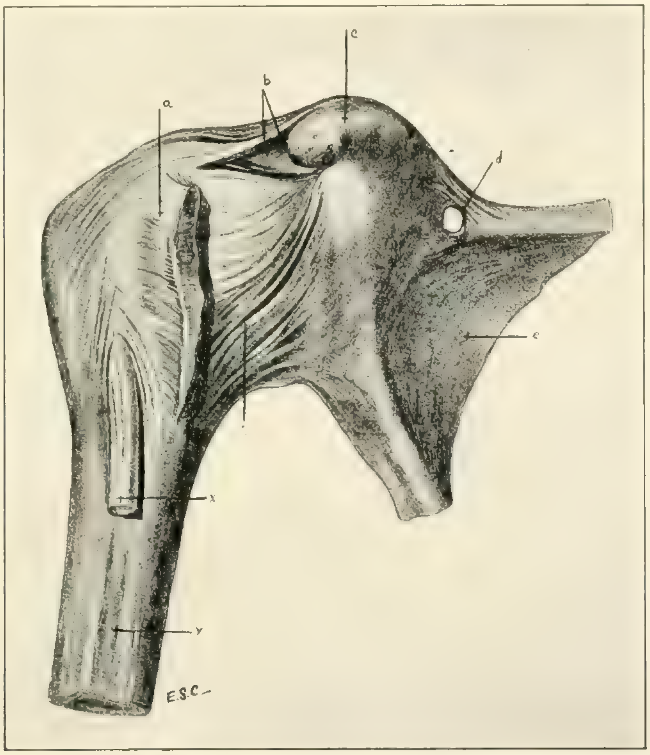


Fig. 218.—Right Shoulder Joint as seen from in Front after Removal of the Skin and Subcutaneous Tissues. (After Spalteholz.) *a*, Subscapular muscle (cut off near its insertion); *b*, coracohumeral ligament; *c*, coracoid process; *d*, superior transverse scapular ligament; *e*, scapula; *h*, joint capsule; *x*, long head of biceps muscle (tendon cut through); *y*, humerus.

The nutrition of the muscles of the shoulder also enters largely into the decision to operate. The operation is most frequently demanded in conditions that have imposed continued disuse upon the muscles and therefore varying degrees of degeneration. Sometimes almost total degeneration will have occurred. Under such conditions an excision cannot be expected to improve motion greatly, and should not be done. A preliminary course of electrical treatment and massage may therefore be necessary before one decides upon the propriety of an excision. These points may be summarized by saying that when the muscles are in good condition we may hope to gain abduction to the horizontal and rotation to a moderate, or even extensive, degree; while the movements in the antero-posterior position, that are so important in guiding the hand in its complicated motions, are practically unimpaired. The preservation of even this range of motion will depend, however, upon accurate preservation of certain anatomical structures and upon an aseptic result. (Fig. 219.)

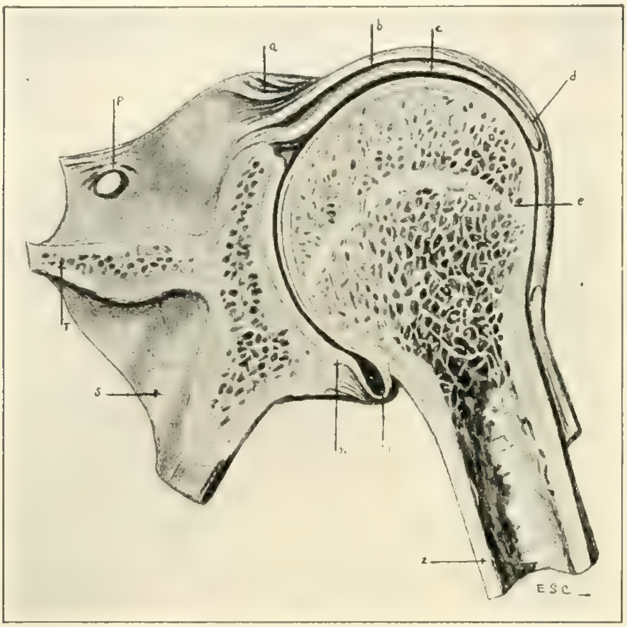


FIG. 219.—Right Shoulder Joint as Seen in Frontal Section. (After Spalteholz.) *a*, Coracoid process; *b*, joint capsule; *c*, long head of biceps muscle; *d*, sheath of biceps tendon; *e*, epiphyseal junction; *p*, superior transverse scapular ligament; *t*, spine of scapula (sawed off at its origin); *x*, glenoid cavity; *y*, capsule of joint; *z*, humerus.

Reference has already been made to the importance of bearing carefully in mind the location of the attachments of the muscles. The close relationship of the important vessels and nerves to the head of the bone, particularly under pathological conditions, constitutes one of the great dangers of the operation. In long-standing cases of dislocation, or of fracture dislocation, altered anatomical relationship will complicate the operation seriously. The circumflex nerve and posterior circumflex vessels pass around the surgical neck in such close relationship to the bone that these structures have a special importance. The bicipital groove is an important landmark and always looks forward in the normal arm. (Fig. 218.)

Indications for the Operation.—(1) Tuberculosis rarely involves the shoulder joint and it most frequently occurs in the form of caries sicca. This condition will therefore call for excision only in those few cases in which pain and functional disturbance persist, in spite of conservative treatment, and in which suppuration develops.

(2) Suppurative arthritis will yield, as a rule, to incisions and free drainage, and, as has already been stated, a resulting limitation of motion or even a partial ankylosis will usually leave a function which equals that to be expected after excision. In cases of disorganization of the joint, however, after rheumatism, gonorrhœa, suppurative osteitis, suppurative epiphysitis, and secondary infection from a suppurative deltoid bursitis, excision becomes necessary.

(3) Ankylosis developing after any one of the above-mentioned forms of arthritis will be subject to the same reasoning that has already been applied. If excision cannot give definite promise of improved motion, or if the muscles show a degeneration that does not yield to appropriate treatment, the operation will be contra-indicated.

(4) Gunshot injuries do not often, at the present day, furnish an indication for typical excision. Even moderate splintering of the bones entering into the formation of the joint will yield to an atypical operation which removes loose fragments and provides aseptic drainage. When suppuration supervenes and when extensive comminution of the head of the humerus is present, a typical resection becomes necessary.

(5) Compound fractures and compound dislocations will be treated according to the same principles that have been set forth for the treatment of gunshot wounds.

(6) In unreduced dislocation of the head of the humerus, Souchon, as quoted by Jacobson, concludes "that reduction should be done only in cases where the head of the humerus and the glenoid cavity are in good condition; when no extensive dissections have to be made; when it is easily effected without great effort; when the head does not need to be trimmed, or the cup to be too deeply scooped or enlarged; when the head readily remains in place, but not too tightly—all this regardless of the time or standing of the dislocation. It should, however, always be attempted conscientiously, because many operators have resected, perhaps, when the dislocation could have been reduced. Disregard of these rules may result in necrosis of the head, in recurrence of the dislocation, or in ankylosis, with their inevitable consequences. Resection should be practised in all other cases. When in doubt, it is better to resect. How much to resect—*i.e.*, when to saw

through the anatomical neck or obliquely and downward outside the tuberosity, or horizontally on a level with the lower margin of the head—must be determined in each case; it is better to remove too much than too little. Of course, all efforts should be made to secure aseptic results. A most important point is to get primary union."

(7) Recurrent dislocation of the shoulder has been very successfully treated by partial excision and suture of the capsule. An excellent operation has been suggested by Burrell and Lovett.

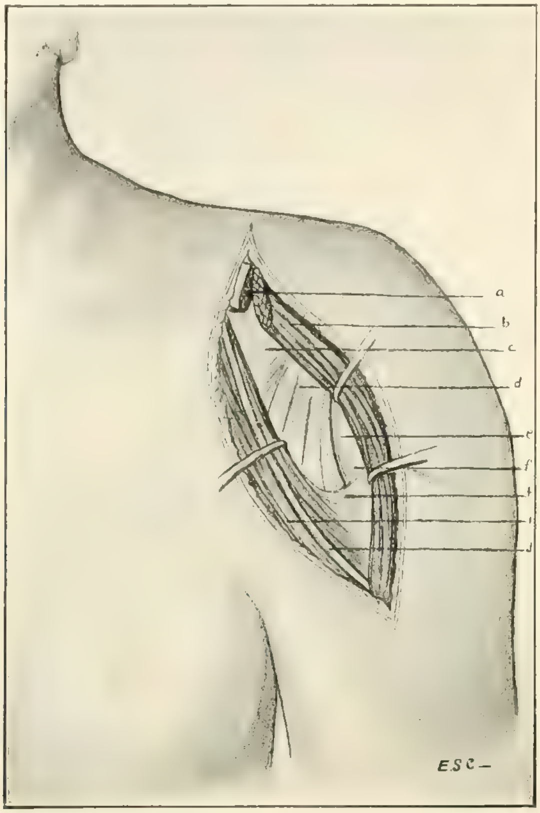


Fig. 220.—Excision of the Head of the Humerus by the Anterior Oblique Incision. Called, by Esmarch, Ollier's method. (After Kocher.) *a*, Cut surface of anterior fibres of deltoid; *b*, deltoid; *c*, pectoralis minor; *d*, coraco-brachialis and biceps (short head); *e*, humerus; *f*, long head of biceps; *h*, tendon of pectoralis major (clavicular portion); *j*, cephalic vein (drawn inward).

(8) Excision may be performed for tumors of the head of the humerus. Many cases of successful excision for osteochondroma have been reported. Stimson has reported a very successful case and expresses the opinion that the operation is a very desirable one to be used in all tumors where the dangers of recurrence are not great. Encapsulated myeloid sarcoma may also be treated by excision, but sarcoma of the upper end of the humerus is usually of the more malignant variety.

THE OPERATION.—The operation of excision of the shoulder joint may be done by anterior incision, posterior incision, inferior incision, and by a deltoid flap.

The operation by *anterior incision* is so generally recommended as the incision of choice for a majority of the lesions requiring operation, that this route will be described in detail.

Place the patient upon the back with the shoulders elevated by a sand bag, and make an incision three and one-half inches long from the base of the coracoid process, and on a level with it, downward in the line of the bicipital groove. (Fig. 220.) The course of the cephalic vein will serve as a guide to the line of division between the fibres of the deltoid and the pectoralis major, and these muscles are to be widely retracted. The bicipital groove and the capsule of the joint will now be fully exposed. The joint is next opened by a longitudinal incision, made on the outer side of the groove, and this incision at the same time liberates the tendon of the biceps. (Fig. 221.) The head of the bone is now examined with the finger, and the

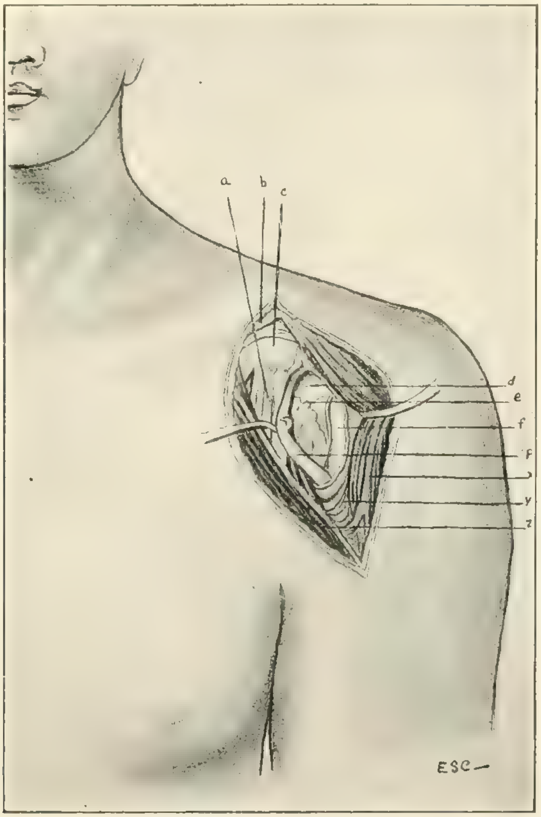


FIG. 221.—Excision of the Head of the Humerus by the Anterior Incision; Second Stage. The biceps tendon is lifted out of its sheath and the joint is opened. (After Kocher.) *a*, Tendon of short head of biceps and coraco-brachialis; *b*, clavicle; *c*, coracoid process; *d*, head of humerus; *e*, place of separation of capsule from anatomical neck; *f*, sheath of biceps tendon; *p*, tendon of biceps; *x*, deltoid muscle; *y*, tendon of pectoralis major; *z*, cephalic veins.

periosteum is divided down to the point of the proposed saw line. Elevate the periosteum outward with a sharply curved raspatory, while an assistant rotates the head firmly inward. When the greater tuberosity is encountered, its attached tendons are divided, or a superficial scale of bone is chiselled away. The arm is then forcibly rotated outward, and the lesser tuberosity is treated in the same manner as the greater. The head of the bone is now ready for excision, either *in situ* or after it has been elevated out of the wound. If the latter course is decided upon, the head is thrust out through the upper part of the wound (after the soft parts have been carefully retracted), by pushing the elbow upward and backward. (Fig. 222.) The bone is then sawed off at the desired point. When it is deemed more desirable to excise *in situ*, a Gigli-Haertel saw is passed around the bone; a flat retractor is so placed as to protect the soft tissues; the head of the bone is seized with a lion-jaw forceps; and the neck is rapidly sawed off. When it is impossible to use the saw, the head may be chiselled out. It is very much better to resect without displacing the head, since this cannot be done without tearing away the periosteum to an entirely unnecessary degree. After the head has been removed, a careful dissection of the joint should be made in cases of disease; foci of disease in the glenoid should be carefully dissected off and the joint closed, with proper provision for drainage. During the dissection the arm should be slightly abducted and flexed, in order to relax the capsule of the joint fully. Whenever conditions will permit, a flap of fat-bearing fascia should be interposed between the bone surfaces in order to secure a new joint at the site of the former articulation.

The site of bone section will determine in large degree the future stability of the joint. A section of bone at the anatomical neck, or a partial resection of the head, will undoubtedly give a much better result than a section at the surgical neck; for this necessitates complete separation of the capsule, detachment of the muscle insertions, serious interference with the triceps tendon, and a considerable shortening of the humerus. This fact, therefore, calls for the utmost conservatism when dealing with the bone. Only just enough bone should be removed to permit of perfectly free mobility. Oftentimes a limited bone section, supplemented by careful gouging out of diseased foci, both in the head of the bone and in the glenoid cavity, will give almost perfect mobility in the joint. In children it becomes a matter of great importance to preserve the epiphyseal line; since the growth of the humerus in length depends mainly upon the upper epiphysis. When a division of the bone at the surgical neck becomes a necessity, the subperiosteal operation should invariably be done if pathological conditions will permit. In sarcoma and in extensive tuberculous disease this will not be possible. In the latter disease, merely segments of the periosteum may be left; but, when even this can be done, bone regeneration is sometimes so satisfactory that almost a perfect result can be obtained. This fact will serve as one more argument in favor of preserving every fraction of an inch of the length of the bone. Unless the end of the humerus can be brought into contact with the glenoid cavity by the contraction of the deltoid muscle, its continued action will not give satisfactory abduction. Typical resection of this and many other joints is certainly very much less frequently performed than formerly, the tendency of modern surgery being to preserve all bony tissue that is not definitely diseased and that can be utilized.

When the operation is done for ankylosis, the chisel and gouge must of necessity be used. In this operation enough bone should be removed to permit of very easy motion in all directions; the upper end of the humerus should be rounded off; the glenoid cavity should be gouged out to resemble the normal structure; and a flap of fat-bearing fascia should be interposed. A special, rather extensive skin incision will be required to procure the necessary flap of fascia.

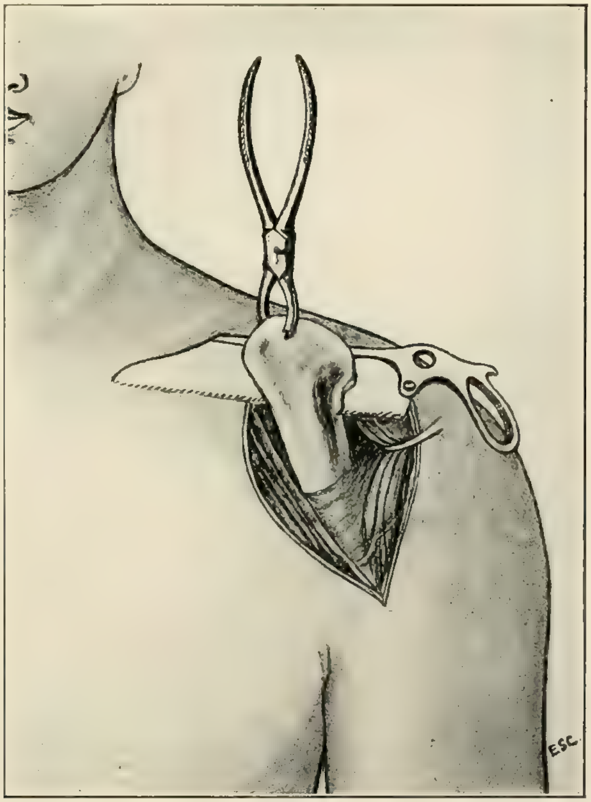


FIG. 222.—Resection of Shoulder Joint. (After Kocher.) Instruments in position for removal of the head of the humerus.

After the operation of excision has been completed, the wound is sutured and a cigarette or rubber tube drain left in for a few days. The arm is immobilized, as in fracture of the upper end of the humerus, by an axillary wedge and a plaster-of-Paris shoulder cap with extensions to the elbow. The hand and the forearm are supported by a sling. Active motion is encouraged in the fingers and passive motion used in the elbow from the first. The time when motion may be made in the shoulder will depend largely upon the nature of the lesion for which the operation has been performed; but, as a rule, it will not be advisable to permit motion sooner than two weeks after the operation, when healing will have been fairly established. The nature and the persistence of the after-treatment will largely determine the result. Massage, electricity, and active and passive movements should be religiously practised for a long time, and every effort should be made to develop those muscles which act upon the humerus independently of the scapula. Abduction is most difficult to regain, and its accomplishment will depend in some degree, as has already been stated, upon the amount of bone removed. Rotation is, of course, preserved when the tuberosities are left, but is frequently regained, even after a typical resection. It is much more likely to be accomplished in a typical operation when the subperiosteal method has been used. Even a passive loose joint may be made very useful.

Senn has recommended an operation which avoids injury to the important structures and gives excellent exposure of the joint. The skin incision is semilunar in form, begins over the coracoid process, passes downward in a gentle curve to the middle of the deltoid, and thence upward to a point behind, which is directly opposite to the point of beginning. This cutaneous flap is reflected upward, then the acromion is sawed across and reflected downward, together with its attached fibres. This gives an excellent view of the joint for erasion or excision. The wound is closed by suturing the acromion back in place and by replacing the skin flap. Drainage may be placed at the most dependent portion of the skin incision by forcing a tube through the deltoid muscle at this point.

Kocher operates by a posterior incision, which is commenced over the acromio-clavicular articulation, extends along, then across the acromion, at a point corresponding to its base, and is continued downward in a curved direction to the posterior fold of the axillary space. The corresponding insertion of the trapezium is divided, and the acromion process is chiselled off near its base. This detached fragment with the attached deltoid is then pushed outward over the head of the humerus, thus exposing the upper and posterior aspect of the joint and the tendon insertions. With ordinary care, the circumflex nerve and vessels will not be injured in this operation; but the chief advantages claimed for it are free accessibility to the cavity, particularly when the posterior part of the joint is involved, and the preservation of the anterior part of the capsule, together with the subscapularis.

Resection for Unreduced Dislocation.—The indications for excision in this condition have been briefly given on page 395, in a quotation from

Souchon's admirable article on this subject. This résumé of indications will lead naturally to the conclusion that fixed rules cannot be established for operative treatment. Each case will present operative indications and operative difficulties which are peculiarly its own. When mild manipulation under an anæsthetic fails to accomplish a reduction, operative measures should be undertaken with the definite idea that the problem is to be worked out after an exploratory incision has been made. When the dislocation is recent, the operation should be done preferably before inflammatory changes set in, or it may be done immediately after such inflammation has subsided. Reduction may be accomplished, in a case of this variety, after the incision has been carried down to the joint, without opening the capsule; or, if reduction cannot be at once accomplished, the cause of the primary irreducibility will be at once apparent. Simultaneous fracture of the neck of the humerus or of the tuberosities, fracture of the acromion or of the glenoid cavity, or a hinderance produced by interposition of the capsule or a muscle may be the cause of such irreducibility. When the case is of long standing, serious obstacles to reduction by any method will arise, as a result of scar formation (involving perhaps the axillary vessels), of muscle contraction, or of some change in the articulating surfaces.

The anterior incision, which has already been described, is, perhaps, the most generally useful for cases of this variety. When excision becomes necessary, the site of division of the bone should again be decided for the particular case in hand, it being always remembered that the resection of bone must be as limited as possible. A division through the anatomical neck, an oblique division downward and inward outside the tuberosity, or a transverse division on a level with the lower margin of the head may be chosen. The object should be to give a primary free mobility. It is better to remove too much than too little. Every effort should be directed to an aseptic result, very complete hæmostasis should be secured, and the wound should be closed without drainage. The same early and persistent attention should be given to massage, passive motion, electricity, and gymnastics that has been advocated after resection for other causes.

In dislocation associated with fracture of the surgical neck, reduction may be accomplished by incision and digital manipulation, aided by the leverage obtainable by the McBurney hook, or excision of the head may be necessary. When the fracture occurs at the anatomical neck, with intracapsular displacement, the only rational treatment is excision; whereas in fracture of the surgical neck excision rarely becomes necessary.

Excision of the Clavicle.—Excision of the clavicle may be required for the removal of either end of the bone, or the entire bone may require removal for a tumor or for necrosis. With ordinary care, this operation is neither difficult nor dangerous when done subperiosteally; yet it becomes a formidable procedure when the bone and periosteum must be removed for the eradication of a malignant tumor. The difficulties encountered will be entirely anatomical. There are no important structures in definite relationship with the outer third of the bone, but structures of very great importance lie very close to the posterior surface of its inner two-thirds. The dangers of injury to these structures will furthermore be very greatly enhanced when the normal relations have been changed by extensive disease.

Resection of the Sterno-clavicular Articulation.—This operation will sometimes be required for the relief of disease. The joint is exposed by an incision made longitudinally to the axis of the clavicle, the periosteum is separated from the end of the bone, and the bone is lifted out with a periosteal elevator and sawed off with a Gigli saw. The sternal portion of the articulation is removed with a chisel or gouge from above forward and outward, in order to avoid possible injury to the jugulars. The clavicle must be carefully held in place during healing; and if there seems to be a marked tendency to displacement, the bones should be wired together.

Resection of the acromial joint may be done through a single longitudinal or a crucial incision. The same method should be employed in the excision of the joint that has been recommended for the sternal joint; and the after-treatment is practically the same.

Resection of the entire clavicle will be most frequently performed for malignant disease. A free incision should be made along the entire length of the bone, and every preparation should be made for prompt action in case of injury to the large veins or the pleura. The dissection should be carried as far as possible from below and from above; then the acromio-clavicular joint should be opened, and the bone lifted strongly forward in order to facilitate the posterior dissection. The attachments of the muscles and ligaments should be divided one after the other as they are encountered, and thus a fair freedom of motion will be obtained by the time the sterno-clavicular articulation is reached. It is important to remember, throughout the dissection, that attachments may have been formed to the underlying structures, and that the traction used to lift out the clavicle may seriously alter the normal positions. It is very easy to injure either a vein or the pleura in this way. If a small rent should occur in the pleura it should be promptly repaired by suture. Special care is needed in disarticulating the sternal end of the bone.

Resection of the clavicle for necrosis is a very simple operation, since it is entirely subperiosteal, and no important structures are endangered.

Whenever the bony continuity of the clavicle is destroyed by either partial or total resection, the after-treatment should be conducted with the patient lying flat on the back and resting on a hard mattress. This position causes the shoulder to pull outward and to rest in a normal position, and it should be maintained until the wound has healed sufficiently to prevent serious falling forward and inward of the shoulder.

Excision of the Scapula.—The scapula is excised because it is the seat of a tumor, or of a necrosis, and also because of injuries which it may have received. Total or partial excision may be required. Total excision is required for the removal of a tumor, while the partial excision of the spine, the angles, and the body will be required for necrosis or for injury. The non-subperiosteal excision should be done when a tumor is present, while the subperiosteal must be strictly followed when one operates for other conditions, because of the importance of preserving the muscular attachments.

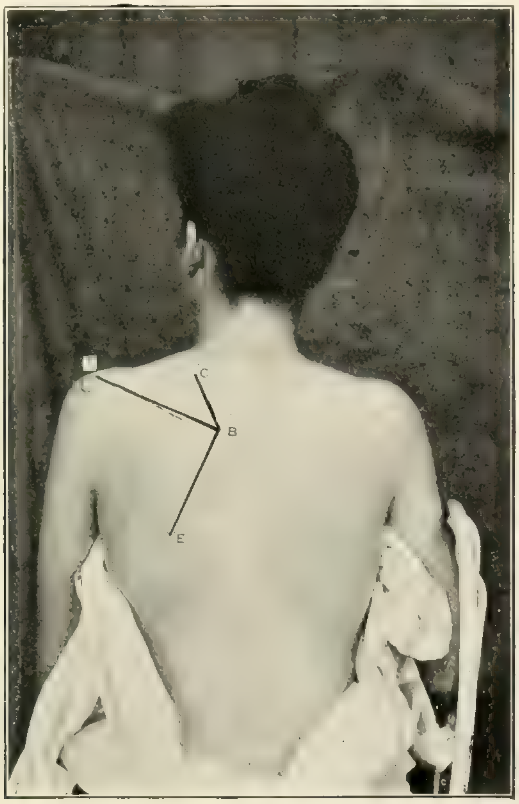


Fig. 223.—Excision of the Scapula. (Original.)

The scapula does not stand in anatomical relationship to any structures of vital importance, yet the operation should in every instance be conducted in such a manner that it will preserve the muscular attachments of the bone and if possible the support of the shoulder through the medium of the clavicle. The suprascapular vessels and nerves are very closely related to the upper border of the bone and will be injured unless their location is kept in mind.

Excision of the Entire Scapula.—The patient should be placed on the sound side, and the arm of the affected side should be placed in charge of an assistant. A transverse incision is first made along the entire length of the spine of the scapula (*AB*, Fig. 223), and a second incision is made along the posterior border of the bone from the posterior superior to the inferior angle (*BE*, Fig. 223). The two flaps thus formed are then dissected up and turned aside. The dissection is conducted far from infected tissue when the operation is done for a malignant tumor, or the flap is made to include the skin, muscle, and periosteum when the operation is done for necrosis. (Fig. 224.)

If the acromion is to be preserved, it is separated from the body of the scapula by chiselling; if not, the acromio-clavicular articulation is opened, the attachments of the deltoid and the trapezius are lifted by the fingers and divided, and the posterior surface of the shoulder joint is exposed. If the operation is done for sarcoma, the rotator muscle should be elevated and removed from the tuberosities. The capsule of the joint is then divided, and the scapula is removed by dividing those structures which are attached to it. The amount of soft tissue removed with the scapula and tumor growth will depend entirely upon the nature and extent of this growth. It is better to commit the error of removing too much tissue than too little. If the glenoid angle of the scapula is to be preserved, it is sawed off, and the shoulder joint is not disturbed. After the dissection has been completed, all bleeding points are carefully secured and ligated, great care is taken to anchor the divided muscular attach-

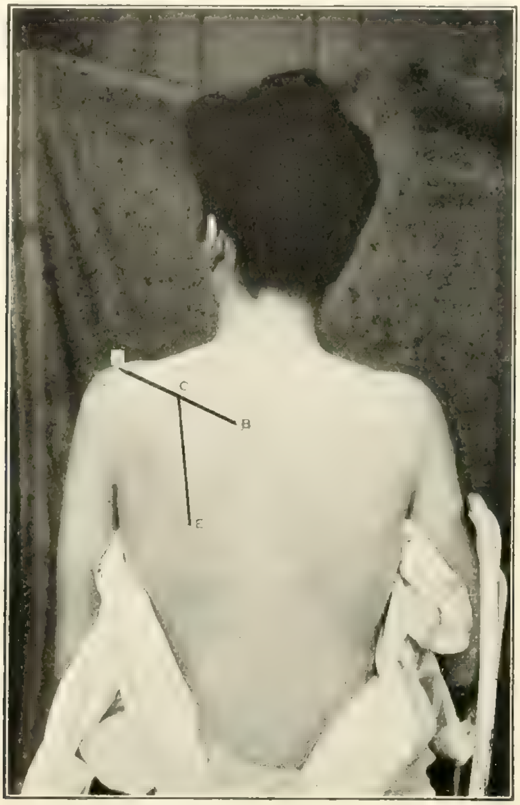


Fig. 224.—Excision of the Scapula. (Original.)

ments and fascia with catgut sutures, and the wound is closed with dependent drainage. The dressing should be voluminous and should be applied in such way as to afford efficient support to the shoulder during healing.

Partial Excision of the Scapula.—This operation will usually be accomplished through an atypical excision which is designed to meet the special indications of the individual case. Whenever it is possible, these incisions should be planned in such a way that the muscles may be separated at their point of attachment and not divided. The angles of the scapula will be removed by a V-shaped incision, the two limbs of which follow the border of the bone. The acromion process and the spine of the scapula are easily removed by a straight or a crucial incision.

Excision of the Glenoid Angle.—This operation is performed for injury, and for disease limited to this portion of the bone. A curved incision about four inches long, which is carried through the fibres of the deltoid and exposes the posterior and upper surface of the joint, is made along the posterior border of the acromion process. From the middle of this incision there is made a second incision, which extends from the upper margin of the glenoid cavity and passes downward through the deltoid and also through the capsule as far as to the centre of the tuberosities. The edges of the wound are now retracted, and the tendons of the biceps and triceps are divided at their points of origin. The neck of the scapula is exposed subperiosteally and removed with a wire saw. The site of this bone section is very deep, and special attention should be given both to hemorrhage and to the protection of surrounding tissues from injury.

In all excisions of the scapula particular care should be taken to place the head of the humerus underneath the head of the outer end of the clavicle, and the capsule should be sutured to the under surface of the deltoid muscle. This gives a fixed position for the support of the shoulder after any one of the scapular operations. The shoulder should be thoroughly supported by efficient bandages and held in place until firm fibrous union has occurred.

The functional result is remarkably good after this operation, and particularly good when the deltoid can be preserved or its attachments restored.

Excision of the Sternum.—Excision of the sternum is an atypical operation which becomes necessary for the removal of necrosed bone or a tumor. Tuberculous disease and typhoid osteomyelitis furnish the most frequent indications for the operation. According to the extent of the disease it may be necessary to remove either a large part of the bone or only a very small section. Except in the case of a tumor the operation should be strictly subperiosteal, and it is particularly important to adhere closely to the bone posteriorly in order to avoid opening the pleural cavity. The operation is conducted through a straight or a crucial incision. When it is performed for necrosis the periosteum is carefully elevated over the front of the diseased area, and then the bone is cautiously cut away with a rongeur or a chisel until the posterior surface is reached. The excision is continued by carefully separating the periosteum posteriorly and biting off small portions at a time with the rongeur. This method of following up the disease is very much safer than if an attempt were made to remove the entire diseased area in a single piece, since with the latter method a certain amount of work must be done in the dark, and the pleura may be injured. In quite a number of cases the ribs will be found to be involved at the same time. If such is proved to be the case this biting away of diseased bone should be extended laterally until solid, healthy bone is found. This point is well illustrated by the case of typhoid osteomyelitis shown in Fig. 225. After all diseased tissue has been carefully curetted away, the skin and periosteal flaps are caused to dip down into the depression by carefully placed gauze packing or by suture, and a gauze dressing is held firmly over this packing by means of straps of adhesive plaster.

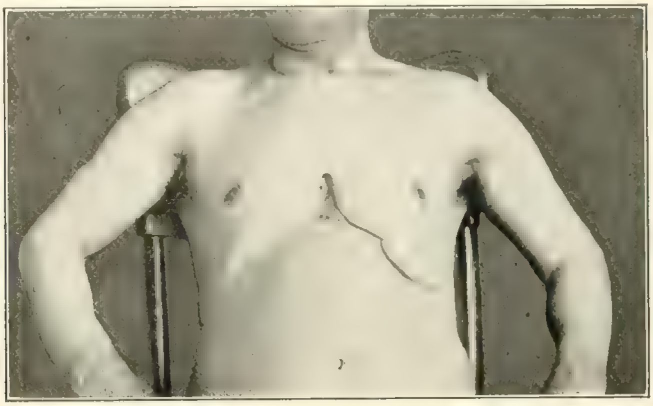


Fig. 225.—Excision of Portion of Sternum, Portions of Two Ribs on Right Side and Three Ribs on Left Side, for Typhoid Osteomyelitis. Photograph taken eleven years after operation. Osteomyelitis became fully developed four months after an attack of typhoid fever in a man thirty-one years of age. Thorax not opened. Wound required three months in healing, and external portion of wound was finally closed by skin-grafting. Patient has been in perfect health since healing of the wound. (Original.)

The operation is usually very successful and is not attended with great danger.

Resection of Ribs.—Resection of the ribs will be required for the purpose of exposing and treating intrathoracic conditions, or it may be done for the removal of necrotic bone. Extensive resection of the ribs for old empyema and temporary osteoplastic resection of the ribs for the exposure of the lung are described elsewhere (Vol. VII.) and need not be considered in this section.

The incision used for resection of a rib is made parallel to the long axis of the bone and of sufficient length to meet the requirements of the case. This incision is carried directly down to the bone, and the periosteum is very carefully elevated until a periosteal elevator can be passed beneath the rib. The rib is then divided with a bone-cutting forceps (*I*, Fig. 207). The cut end of the bone is now seized and lifted out of the wound with a sequestrum forceps (*J*, Fig. 207), and the remainder of the subperiosteal dissection then becomes very easy. When the desired amount of bone has been enucleated from the periosteum, it is again divided with a saw or forceps and removed. The periosteal groove now lies at the bottom of the entire length of the wound. If the resection has been done to facilitate drainage in empyema, an incision is made into the pleural cavity, in the bottom of the periosteal groove. If the resection has been done for the removal of necrotic bone, the wound is packed with gauze and allowed to heal by granulation.

Very satisfactory regeneration of bone takes place after such an operation and the results are usually good.

Excision of the Elbow Joint.—The anatomical arrangement of the elbow joint is particularly favorable to good results after excision. It is a simple hinge joint; the entire extent of the synovial membrane can be readily exposed by incisions that do not seriously damage important structures; and the joint is surrounded by powerful muscles whose attachments can be either preserved or restored. A further argument in favor of the more frequent application of the measure, in diseases or injuries of this joint, is found in the fact that ankylosis in good position after such an operation, even though undesirable, will nevertheless give a very useful and powerful arm, because of the free motion in the shoulder and scapula.

The indications for the operation are: (1) Fungous tuberculosis; (2) recent injury; (3) old injury with ankylosis; (4) suppurative arthritis which does not yield to drainage; (5) old dislocations; (6) some cases of epiphyseal injury; (7) osteo-arthritis; and (8) new growths.

Tuberculosis will undoubtedly furnish the most frequent indication for the operation. The general principles involved in the decision to operate upon a tuberculous joint are discussed on page 435, and need not be repeated. When, in a case of tuberculous elbow, the recognized non-operative measures of treatment fail to promise a cure, with motion, and when due consideration has been given to the general principles discussed on page 435, no time should be lost in recommending excision. von Bergmann believes that, "in spite of the good results of primary conservative methods, there is no doubt that a broad field lies open for total resection in the case of tuberculosis of the elbow, and that the procedure is capable of giving good results." He then quotes the statistics of Kœnig and Kocher. Koenig's statistics for complete resection are as follows: Complete recovery, 54 per cent; incomplete recovery, 8 per cent; deaths, 38 per cent. For incomplete resection and other treatment the results are as follows: Complete recovery, 32 per cent; incomplete recovery, 8 per cent; deaths, 61 per cent. The functional results, in 45 cases of complete resection with complete recovery, showed: 60 per cent of recoveries with more or less motion and good power; 33 per cent with ankylosis and satisfactory power; and 7 per cent with loose joints. Kocher reports a good working arm and hand for even hard work in 64 per cent, and a capacity for only light work in 36 per cent. Koenig's statistics show somewhat better results after complete than after incomplete resection, and some authors state definitely that the complete operation should be performed, for the reason that tuberculosis of the bone is more frequent than tuberculosis of the synovial membrane, and that the bone lesion is usually multiple. Yet perhaps a majority of writers are to-day agreed that partial resection is always to be preferred to total resection in cases in which only a portion of the joint is diseased. Erasion also has a definite field of usefulness in the purely synovial type of the disease. The author has operated by erasion, in one case of this variety, and obtained a perfect recovery, full range of motion, and a capacity to do full hard labor in a foundry. This case has now been under observation for more than two years since the operation. No fear of disseminating tubercle bacilli throughout the system should be entertained, since this accident is peculiarly infrequent after operations upon the elbow.

Primary excision for injury will rarely be indicated, except in a limited number of cases of gunshot wound and compound fracture, in which the articular ends of the bone are badly shattered, and in the clearly infected cases of ordinary compound fracture. In a very large percentage of cases of compound fracture of this joint (and of other joints), particularly when the bone fragments are not detached from the periosteum and soft parts, a painstaking aseptic and antiseptic technique will yield very remarkable results without a resort to excision. Thorough sterilization of the surrounding skin, copious flushing of the wound with warm salt solution, careful replacement of the fragments of bone, slight primary closure of the external wound by suture, drainage of the joint for forty-eight hours, and a wet dressing of acetate of aluminum are measures from which much may be expected; and the author believes that they should first be tried in all such injuries, unless their seriousness is such as to preclude all hope from the start. In all fractures of the lower end of the humerus the author has experienced additional satisfaction from the use of the acutely flexed position. Should suppuration develop in a joint that has been treated in this conservative way, a prompt secondary partial, or total, excision should be done. This operation should be performed either very promptly, for the purpose of securing drainage, or at a later stage, after the active inflammation has somewhat subsided. When excision is done, either primarily or secondarily, the operation should partake more of the nature of a trimming of sharp angles than of that of a typical resection; and it is certainly unnecessary to locate the saw section above the upper limit of a longitudinal fissure. The olecranon process should always be preserved, if possible, as a safeguard against a loose joint.

T- and Y-fractures, occurring as they do only after very severe and usually compound injuries of the elbow, will be frequently encountered in compound injuries of the elbow. Favorable results have not been obtained by the ordinary methods of treatment in either simple or compound T- and Y-fractures, and Kocher has suggested, for such cases, resection of one or both condyles. The results were not good, however, since the operation left a flail joint. It seems to the writer much more rational either to replace these fragments by the aid of the *x*-ray, or, failing in this, to nail or suture the fragments together. Should union in a bad position result, it is then time to recommend such operations as chiselling away exuberant callus in the supratrochlear fossæ, the making of a wedge-shaped resection of the humerus, or other plastic operation, in order to increase the range of motion, before recommending excision.

Old injuries of the elbow with resulting stiffness, or with ankylosis at a useless angle, will present difficult problems in treatment; and, in so far as this is possible, the cause of the limitation in motion should be discovered before an operative plan of treatment is decided upon. A careful series of *x*-ray pictures will lend valuable aid in this direction. Forcible movement of the joint under an anæsthetic will rarely accomplish much unless the stiffness is the result of adhesions which have developed in the joint from the organization of fibrin. Arthrotomy for the division of adhesions and restricting bands may accomplish a great deal if the synovial membrane is wholly or partially intact, but it can accomplish but little when this membrane has been lost. Partial or total excision then becomes the alternative; and the result from either of these procedures will depend upon the general vitality of the patient, the nutrition of the muscles, and the nature of the lesion for which the operation is performed. In adults, where there has not been a suppurative inflammation; where the periosteum has not been stripped up, leaving bands that may subsequently ossify; and where the cartilages are not destroyed and the muscles are good, a resection of the humerus alone, above the trochlea, will give an excellent result. A partial resection was formerly considered to be undesirable, indeed contra-indicated, when these conditions did not exist. The reasoning has of late been very greatly modified, however, by the development of the operation of arthroplasty. We now feel that, when the humerus has been resected to a degree sufficient to give a movement so free that the hand can be carried to the shoulder of the same side and behind to the scapula of the opposite side without locking, a satisfactory result will be assured by transplanting a flap of fat-bearing fascia over the end of the divided humerus. This measure favors the development of a useful joint, and the preservation of the olecranon with its sigmoid cavity becomes a potent factor in giving stability to the new joint. This operation has therefore improved the treatment of ankylosis and seems particularly adapted to the elbow joint. The great importance of this procedure depends upon the fact that partial resection may be done in ankylosis and in injury. In both of these conditions partial resection has formerly been followed, in many instances, by ankylosis; and an excess of resection, by a loose joint. The difficulty experienced in the partial operation was that the bony surfaces became reunited; and, in the over-complete operation, there followed a long flexible fibrous union, which could not give stability. In the arthroplastic operation it is possible to leave the rounded-off end of the humerus in loose contact with a normal or constricted sigmoid cavity, without fear of bony union; and the great advantages that result from stability of the joint are at once apparent.

Unreduced backward dislocation of the elbow will usually require operative relief after the lapse of three or four weeks, because of shrinking and cicatrization of the soft parts. Several methods of operating have been suggested. Trendelenburg and Voelker advise a transverse section of the olecranon at its base with a sharp chisel; replacement of the bones of the forearm; and reunion of the separated portions of the olecranon with wire sutures. von Bruns recommends a partial resection of the joint by two lateral incisions. He resects one and one-half or two inches of the lower end of the humerus. This operation is rendered rather difficult by adhesions and by cicatrization of the soft parts; yet it seems to be the most rational procedure in those cases which are not suited to the von Eiselberg operation. The operation should not be done in children, since it involves a removal of the epiphyseal line. In adults the field

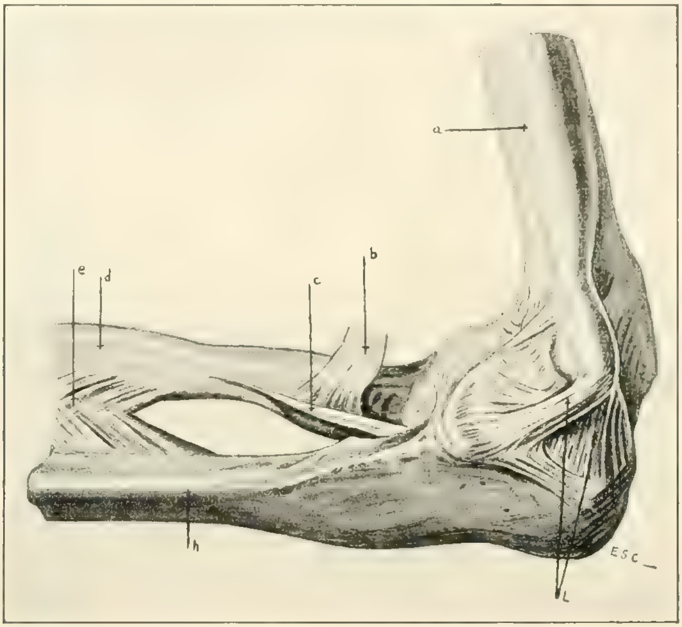


FIG. 226.—The Ligaments of the Elbow. (After Spalteholz.) *a*, Humerus; *b*, tendons of biceps muscle (cut through); *c*, oblique ligament; *d*, radius; *e*, interosseous membrane of forearm; *h*, ulna; *l*, lateral ligaments.

of application of the operation has been materially broadened by the arthroplastic methods already described. von Eiselberg believes that the irreducibility depends wholly upon cicatricial bands, interposed soft parts, and adhesions; and he has reported excellent results from arthrectomy which removes all such obstacles to reduction and restores a normal joint. Two lateral incisions are made, and the ends of the bone are carefully freed of all bands and adhesions, before the reduction is made. This operation should certainly be attempted in every case; and, when it is found impracticable, partial resection, as recommended by von Bruns and supplemented by an arthroplastic flap of fascia, should be employed.

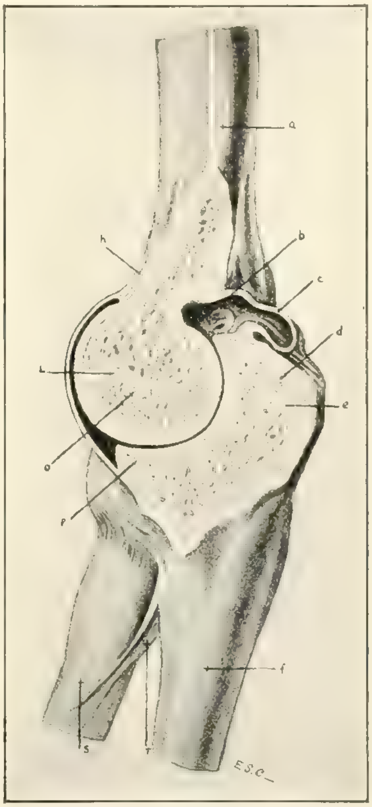


FIG. 227.—Longitudinal Section through the Normal Elbow Joint, Showing the Expansion of the Synovial Membrane. (After Spalteholz.) *a*, Humerus; *b*, olecranon fossa; *c*, joint capsule; *d*, olecranon; *e*, epiphyseal junction; *f*, ulna; *t*, oblique ligament; *s*, radius; *p*, coronoid process of ulna; *o*, trochlea of humerus; *l*, epiphyseal junction; *h*, coronoid fossa.

Epiphyseal injury, although of rather infrequent occurrence, may require operative treatment. The author has always been able to reduce the deformity in cases of this sort and retain the fragment in place by utilizing the position of acute flexion of the elbow; but many cases are on record which have demanded operative replacement or excision of the displaced epiphysis.

ANATOMICAL CONSIDERATIONS.—While no part of the anatomy of the elbow joint (Fig. 226) may be disregarded in performing an excision, particular attention should be directed to the following points: (1) The elbow is a hinge joint, and the muscles are arranged for the production of the movements which belong to a joint of this variety. This fact renders necessary the preservation of the olecranon process, or a portion of it, whenever it is free from disease. (2) The periosteum of the bone is not arranged in a way to give material aid, if preserved; and therefore very little attention need be paid to its preservation, except at the sites of muscular attachment. If the periosteum is preserved at the outer and inner sides, a sufficient lateral stability will be secured. (3) The olecranon, coronoid process, and tubercle of the radius should be preserved, when possible, because of their muscular attachments. (4) The ulnar nerve should be carefully guarded against both division and pressure during the dissection of the inner condyle. (5) The functional value of the supinator brevis muscle and the fact that the posterior interosseous nerve passes through the muscle should be constantly kept in mind during the excision of the head of the radius.

THE OPERATION.—Of the many incisions that have been described for excision of the elbow, the posterior longitudinal incision of Langenbeck will be found most satisfactory (*a*, Fig. 228). The forearm is held firmly in a position of complete extension, and a straight longitudinal incision, at least five inches long, is made behind the joint, at an equal distance from the two condyles. This incision begins in the middle of the olecranon, is made down to the bone, and splits the triceps tendon. The periosteum over the olecranon process is now elevated inward with periosteotome and knife, and the tissues above this process are strongly retracted inward. This dissection is carried inward as far as the tip of the inner condyle and should adhere closely to the bone in order to protect the ulnar nerve. The muscle attachments to the inner condyle should be separated subperiosteally, and, when disease does not prevent, a thin slice of bone should be chiselled off. The tissues on the inner side of the incision should now be allowed to fall back into position, and an exactly similar dissection should be made in an outward direction. When the attachments of the external lateral ligament and the external muscles have been completely separated, the tissues on both sides of the incision are strongly retracted; the elbow is flexed; all parts still tense are divided; and the extremities of the bones are forced through the incision. When the operation is done

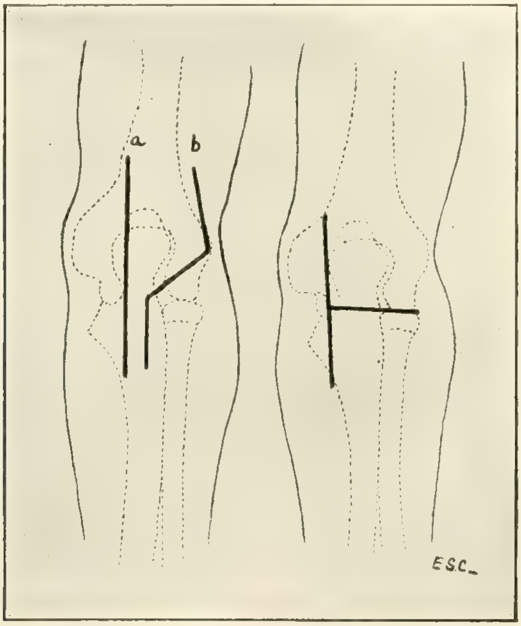


FIG. 228.—Excision of the Elbow Joint. (After Bryant.) *a*, Langenbeck's incision; *b*, Ollier's incision; *c*, the incision of Liston and of von Bruns.

for fungous tuberculosis, a subperiosteal separation of the lateral structures may be impossible.

Surgeons differ as to which bone should be excised first; but this point possesses a minor importance when compared with the exact site of bone section. Fear of a loose joint is very apt to cause the inexperienced operator to remove an insufficient amount of bone, and then an imperfect result will follow. As a rule, the olecranon should be first sawed through from behind at a level which will remove the greater and lesser sigmoid cavities; then the radius should be removed just below the head. The error of removing an insufficient amount of bone arises in the case of the humerus. The line of section should pass above the level of the epicondyle on the outer side and through the highest part of the epitrochlea on the inner side. A section which removes only the articular surface and passes through the lower part of the coronoid and olecranon fossæ will not be sufficient. As a test of sufficient removal of bone, Jacobson states that the mobility should be sufficient to permit the hand to be placed "not only on the shoulder of the opposite side, and to the mouth, but on the shoulder of the same side, and behind the back to the angle of the opposite scapula." Removal of this amount of bone will leave an interval of about one inch and a half between the cut ends of the bones. This interval is considered to be about correct.

When the bones have been divided, the synovial cavity is fully exposed for complete dissection in the case of disease. In tuberculosis, a systematic plan should be followed, and every particle of suspicious tissue should be removed by sharp dissection. Any foci of disease left in the bones should be cut out with a strong-bladed knife; particular attention should be given to extensions downward from the radio-ulnar articulation; and any cavities left in the bone should be filled with Mosetig-Moorhof's iodoform bone-plugging material. (See Vol. I., p. 724.) A roughening of the periosteum above the line of bone section does not necessarily mean tuberculous invasion. Finally, sinuses and pockets should be carefully dissected out or curetted, and the entire area of infection should be thoroughly mopped—first, with pure carbolic acid, which is left in contact for about a minute, and then with alcohol; and the wound will then be ready for closure. Opinions differ as to whether it is best to remove the tourniquet before closing the wound or after the dressings are applied. The writer believes that it will always be far safer to remove the tourniquet and secure all bleeding points before closing the wound.

The wound is not sutured except at the ends, liberal drainage is introduced, and the arm is immobilized in a position of semi-flexion and midway between pronation and supination. For this purpose a wire splint, such as has been recommended by Esmarch, or an anterior strap splint of plaster of Paris, reinforced by a metal bar, or an interrupted plaster splint may be used. Any splint used for the purpose should furnish efficient immobilization and, at the same time, should permit the wound to be dressed without disturbing the position of the bones.

The wound should not be dressed for from five to seven days, unless definite indications arise. The fingers and wrist should be moved on the second day. The elbow should not be moved until the wound has healed sufficiently to give stability to the joint, that is, in about three weeks; and when this is done the bones should be held in their respective positions. Passive motion is advocated by some surgeons at a much earlier date; but this course does not seem desirable to the writer, since early manipulation is certain to keep up the inflammatory reaction and cause an induration which will delay rather than hasten the result. Motion at the end of three weeks will undoubtedly produce some inflammatory reaction; but this will be slight, and the tissues are at that time in much better condition to be mobilized. The movements should be very gentle and limited in their range at the start, then they should be gradually increased, until recovery is complete. The movements practised should be flexion and extension at the elbow and rotation of the forearm. When rotation of the forearm is being made, the ulna should be held in a fixed position and the radius gently rotated. After healing has progressed fairly well, the patient should be encouraged to use the joint more and more in light exercise, and finally gymnasium work should be prescribed. The after-treatment of such cases becomes a very difficult matter when the patients are young children. A child naturally refuses to use a painful joint; the parents, furthermore, have not the heart to carry out such instructions, and too often they are quite as difficult to manage as the little patient, when they are called upon to witness the necessary pain that is inflicted by the surgeon. It is often necessary to anæsthetize the child several times, in order to gain the range of motion that is desired. Gentle and systematic massage, given by a nurse who can gain and retain the confidence of the little patient, is indispensable. Falls on the elbow should be carefully avoided.

The operation described above refers to complete excision of the elbow joint; yet, as has already been stated under the heading of Indications for the Operation of Excision, this complete excision is not often performed unless it is demanded by extensive disease. Even in tuberculous joint disease, the olecranon should be preserved when it is not definitely diseased. The author has derived much satisfaction from the incision described by Liston and von Bruns and from the bilateral incision of Hueter, which is to be employed when the olecranon is to be preserved.

In Liston's operation (*c*, Fig. 228) the joint is opened by a longitudinal incision three or four inches long, which is made along the inner border of the olecranon. A second transverse incision starts over the radio-humeral articulation and extends to the first incision. This incision is carried down to the bone and opens the radio-humeral joint. The olecranon is next sawed off at its base and reflected upward and outward with the attached triceps muscle. The remainder of the dissection is conducted in a manner similar to that already described. When the operation has been completed, and all diseased bone has been removed, the olecranon is sutured in place. This operation gives a most excellent exposure of the joint for erasion in synovial tuberculosis and for excision, partial or complete, when this is necessary. Resuture of the olecranon restores the posterior support of the joint and leaves the function of the triceps muscle practically unimpaired.

The employment of two lateral incisions has been frequently resorted to by Hueter, Ollier, and others, and seems particularly adapted to cases of ankylosis and to those in which a partial excision, with or without arthroplasty, is required. A short, vertical incision, about one inch long, is first made slightly in front of the inner condyle, and the muscular and ligamentous attachments to this prominence are carefully detached. A radial incision, four inches long, is then made with its centre over the external condyle, and the structures attached to this point are dealt with in a similar way. The incision is carried through the orbicular ligament and exposes the head of the radius, whereupon it can be removed, if deemed wise, either with a saw or with a bone-forceps. The humerus is either exposed by careful retraction and divided in the wound by a narrow saw, or it is thrust through the outer wound and sawed off. If a complete excision is to be done, the olecranon can be dissected out and removed. As has already been stated, however, partial excision will be done in most cases of ankylosis, injury, and unreduced backward dislocation, and the humerus alone will be resected. When the operation is done for any one of these conditions, the outer skin incision should be very greatly extended, in order to obtain a fascial flap of sufficient size to extend entirely across the joint and cover the lower rounded end of the humerus; the operation should then be completed in accordance with arthroplastic requirements. This measure will undoubtedly add very greatly to the success of such operations, since it will not only insure to a large degree a movable joint, but will also, by reason of the preservation of the olecranon, give a joint of very strong action.

Ollier's bayonet-shaped incision (*b*, Fig. 228) has been advocated as giving more room for manipulation, a more satisfactory wound for after-treatment, and an operation better suited to partial excision, should this be found desirable after an exploratory incision. Ollier's incision was originally designed for the treatment of ankylosis in the extended position. The incision begins on the outer side of the arm, two and one-half inches above the joint, in the groove between the triceps and supinator longus, and is carried downward to the tip of the external condyle. It then takes an oblique course downward and inward to the base of the olecranon, and finally descends vertically for a distance of two inches along the posterior border of the ulna. A second incision one inch long is made over the inner condyle, for the purpose of detaching the muscle and ligament from this structure. The remainder of the operation is conducted in accordance with the principles already given.

The result, after excision, will be estimated upon a basis (1) of the cure of disease, and (2) of the range of motion at the elbow. Damianos gives the following statistics for excision of the elbow in tuberculosis of this joint: In a series of 32 cases, no patient died from the operation. Of 20 patients concerning whom a subsequent history could be obtained it was found, at least one year after operation, that in 10 cases the elbow had completely healed without fistula, swelling, or pain; that in 1 case there remained unimportant fistulæ which were almost closed; that 3 required slight subsequent operations; that 6 had died, after the expiration of one year, from pulmonary tuberculosis. and that good motion had been obtained in 21.4 per cent, slight motion in 50 per cent, and ankylosis in 28.6 per cent of these cases. Some of these patients could do heavy work, while others were able to do only light work.

When the wound does not heal after excision for tuberculosis, it may be assumed that infected material is still present in some portion of the wound; and a prompt secondary operation should then be done to remove this focus, which is usually so small that a very slight operation will accomplish the purpose. This operation will consist in thoroughly opening up sinuses, in removing by curettage or sharp dissection all suspicious tissue, in thoroughly mopping the wound with pure carbolic acid, and in leaving the wound wide open for treatment. It is very comforting to know that a dissemination of the infection to other parts of the body rarely follows excision of the elbow for tuberculosis.

In such conditions as ankylosis and unreduced backward dislocation the result will be estimated almost solely upon a basis of restored motion. It may be assumed that a good result has been obtained when the patient can, in about four months, move the joint freely and use it efficiently in feeding and dressing, and can do light work. In one year the joint should be firm and strong and should be equal to hard work. As has already been stated, the completeness of the result will depend very largely upon the method of operating. Any lateral or forward displacement of the forearm while it is in the splint, the resort to passive motion at too early a date, or the wasting of the muscles may be a direct cause of a flail joint. The result of the operation may therefore be a complete success, a partial success, or a failure, *i.e.*, a condition of ankylosis or a loose joint. It is firmly believed that arthroplasty will very greatly reduce the number of failures after operations of this type. Indeed, failure should not often occur when a proper technique is used.

Should ankylosis occur after excision by one of the usual methods, a further operation has been looked upon as inadvisable, since a loose joint is likely to result. Cases of this type should be carefully studied, however, in order to determine whether an arthroplastic operation or an osteotomy, for the purpose of securing bony union at a useful angle, will not improve the functional value of the elbow.

A loose joint should be treated either by the application of a carefully constructed supporting apparatus, or by an operation designed to give bony union at a useful angle. Kocher uses a support which consists of two leather collars, fitting closely around the arm and forearm and connected laterally by two metal bars, which can be clamped at any angle. This may be used, during convalescence, in those cases which do not ultimately gain an entirely strong joint and need additional support when doing heavy work; or it may be used in the hopelessly loose joint. In this way a permanently loose joint may become very useful to a patient.

Erasion of the Elbow Joint.—Erasion of the elbow joint has not been extensively done; yet the writer is of the opinion that the method should receive careful study, and that it possesses a wider field of application than has thus far been assigned to it. In synovial tuberculosis and in those cases which show a very limited bone lesion the technique described below will give results that could not be obtained from excision. Excision cannot promise motion without removing the epiphyseal end of the humerus; and, in children, this loss of the epiphyseal line means a very serious shortening. The synovial membrane can be very completely exposed to view by the von Bruns incision and a complete dissection can be made. The following case, seen with Dr. Frank Perry, of Norwood, Ohio, will illustrate these points very well:

The patient, a foundry worker, aged 27, had suffered for a few weeks from rather acute symptoms of arthritis in the elbow joint. Immobilization for three weeks gave no results, and the patient, who was a poor man, became very much worried over the prospect of a prolonged period of immobilization. Operation was suggested and promptly accepted as the alternative. The joint was opened by the von Bruns method, and at least one ounce of a material like curd and whey was evacuated. The entire synovial membrane was covered by tuberculous granulations, and there was a limited superficial ostitis in the radio-ulnar articulation. The articular ends of the bones were glistening and uninvolved. A careful, sharp dissection was made, all raw surfaces were mopped, for about one minute, first with pure carbolic acid and then with alcohol, and the joint was closed with free drainage. The drainage was removed at the end of forty-eight hours. The fingers and wrist were moved from the start, and the elbow only after the lapse of three weeks. At the end of six weeks the motion was good and unaccompanied by pain. In about ten weeks the patient began to work regularly, handling section bookcases, and at the end of six months he returned to his regular work in a foundry. By this time the elbow had regained all motions completely, the arm was almost as strong as formerly and gave no symptoms. At the present time, after the lapse of two years of continuous work, these same favorable conditions are maintained. I should add that the diagnosis of tuberculosis of the elbow joint was confirmed by a careful microscopic examination.

So far as could be judged from the symptoms, this patient suffered from a purely localized tuberculous inflammation, which threatened the joint, possibly the life. There must obviously have been a tuberculous focus elsewhere in the body, from which the joint became infected through the circulation; yet the uncertainty as to the nature and locality of this primary focus, and the infrequency with which other similar lesions develop, justify us in disregarding it, in directing our attention to the only evident seat of tuberculous disease, and in dealing with the joint lesion as though it were purely localized. Within this joint the tuberculous lesion was strictly limited to the synovial membrane, and there was no indication for removing good bone, covered by normal articular cartilage. It is quite obvious that erasion can give a movable joint only when the articular cartilages are normal, and that this operation will be applicable only in early cases. It is therefore recommended that the operation for tuberculosis of the elbow should be undertaken with the idea that erasion, partial excision, or total excision may be best suited to the individual case; and that consequently an incision should be used which will answer for either one of these three procedures. The von Bruns incision has, in the writer's experience, fulfilled these requirements.

Excision of the Radius.—This operation may be necessary for either the partial or the total removal of the bone. The head of the bone may require excision in cases of fracture-dislocation or in old unreduced dislocation of the head where the movements of the forearm are much hampered. The writer has seen, with Dr. Cadwallader, of Norwood, Ohio, a case of compound fracture-dislocation of the head of the radius in which excision was demanded:

In this case a very heavy man, 40 years of age, fell about ten feet from a roof and sustained a severe injury to the elbow, with evident fracture and a small wound over the head of the radius. The head of the radius was found to be almost free in the deeper parts of the wound and was easily removed. The wound healed promptly without infection. After painstaking massage and passive motion, twice under an anæsthetic, this patient regained complete motion in the elbow joint, and three months after operation he reported to the writer that he had on that day used this arm for nine hours continuously in driving spikes.

When the operation is done for old unreduced dislocation, an incision two inches long is made over the prominent head of the bone; the fibres of the supinator longus are separated, with due regard for the musculo-spiral nerve; and the bone is exposed and cleared by blunt dissection. The head of the bone is removed with a Gigli saw or with a cutting bone-forceps; the forearm is then moved freely, but carefully, in order to break up adhesions; and, finally, the limb is immobilized, until the appropriate time for passive motion shall have arrived.

The shaft of the bone or a portion of the shaft may require excision, as, for example, after extensive osteomyelitis. The incision for exposing the bone should be made over its most superficial portion. The general principles of excision of bone have been discussed under the heading of Excision of the Tibia and Fibula (page 455), and need not be repeated at this point.

Excision of the Wrist.—Excision of this joint presents difficulties which are quite out of proportion to those encountered in other joints. The complicated nature of the articulations and the irregularity of the synovial membrane render the region particularly subject to a progressive extension of a tuberculous or septic process, and increase greatly the likelihood of overlooking side extensions of disease when an operation is performed for its eradication. The close relationship of the flexor and extensor tendons to the joint, running as they do, in many instances, in grooves in bones, introduces a second difficulty. Injury to these tendons will interfere seriously with the result, or added difficulties will be presented by the very frequent extension of the tuberculous process to the tendon sheaths themselves. The great variety and the delicacy of the movements of the wrist will make it difficult to obtain satisfactory functional results. These difficulties all contribute to bad or indifferent results, and the operation of excision of the wrist has not enjoyed the favor that has been accorded to the same operation in other joints. Recurrence of a tuberculous process, locally, has been frequent; pulmonary tuberculosis has developed; matting or sloughing of the tendons has caused a fin-like hand; and ankylosis has occurred. It is undoubtedly true, however, that, as a result of such experiences, conservatism regarding operations upon this joint was formerly carried too far; but it is the writer's belief that the field for the application of this operation has of late years been greatly extended. The difficulties enumerated will direct our attention very strongly to the necessity of carefully selecting the cases for operation. There are some cases, for example, that are clearly unsuited to excision, by reason of the extent of the disease, the degree of atrophy of the muscles, or the general condition of the patient; and, when this is the case, the alternative amputation should be applied. There are other cases in which a partial excision or a conservative atypical operation will yield results superior to excision.

The indications for the operation are: (1) Tuberculosis of the radio-carpal, carpal, or carpo-metacarpal joints, alone or combined, requires excision. (2) Suppuration of the joints may require excision, for the purpose of securing proper drainage. The articular surfaces of the radius and the ulna should be preserved if possible. The functional result, after operation for this condition, is almost certain to be incomplete, especially when the tendon sheaths have been involved in the inflammatory process. (3) Complicated injury to the joint, as in gunshot wounds and in compound fracture, may require excision. This should not be done as a primary operation, however, and not until a careful review of the situation has shown that aseptic wound treatment and careful plastic repair of the damage done to the joint are impracticable. Quite unexpected results will oftentimes be obtained by this procedure, and the patient will be saved the more extensive operation of excision or amputation.

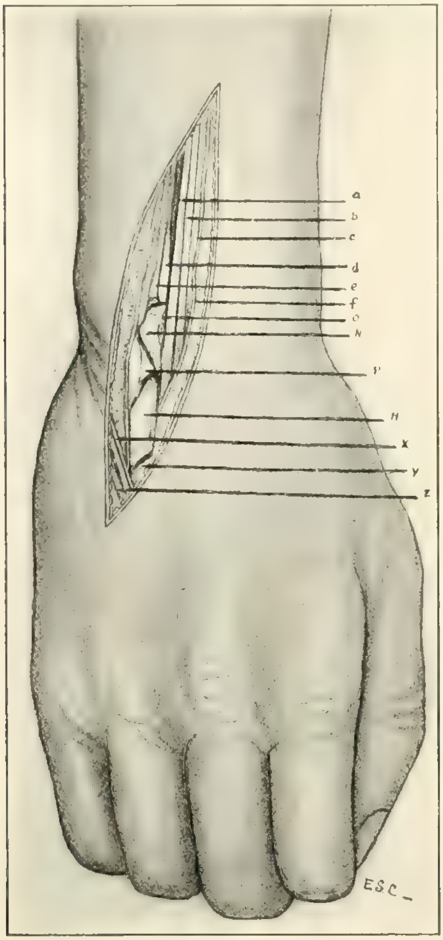


FIG. 229.—Excision of the Wrist by the Dorso-ulnar Incision Carried through the Capsule. (After Kocher.) *a*, Tendon of extensor minimi digiti; *b*, tendons of extensor communis digitorum; *c*, fascia; *d*, radius; *e*, ulna; *f*, posterior annular ligament; *o*, triangular fibro-cartilage; *n*, semilunar bone; *p*, cuneiform bone; *h*, unciform bone; *x*, dorsal branch of ulnar nerve; *y*, base of fifth metacarpal; *z*, posterior ulnar vein.

ANATOMICAL CONSIDERATIONS.—Reference has already been made to the complicated nature of this joint, and it may be safely asserted that there is scarcely a point in the anatomy of the region which does not require careful review before this very difficult operation is undertaken. There are many irregular bones making up the joint, and these bones are firmly bound together in every direction by ligaments which permit of but limited movement between the articular surfaces. The synovial membrane is divided into five distinct cavities, any of which may be diseased or not. The joint is surrounded by important tendons, nerves, and blood-vessels. The period of development of the epiphyseal centres should also receive careful consideration when the conditions are such as to call for an atypical excision. It is an established rule that this excision should be subperiosteal, and the joint should be studied anatomically, with this point in view. The location of tendon insertions should be accurately known by the operator. Tendons should not be divided, unless it become imperative, and in this instance both the tendon and its sheath should be accurately reunited.

THE OPERATION.—Kocher resects through a single incision on the dorsum. (Fig. 229.) The hand is placed on a sand bag in a slightly flexed position, and a skin incision, four inches long, is made from the middle of the interspace between the metacarpal bones of the ring and middle fingers, upward and outward, in an oblique or somewhat curved course, toward the radius. The deeper structures are now divided by an incision between the extensor communis digitorum and the extensor of the little finger, and the joint is opened below. The tendon of the extensor carpi ulnaris is detached from the fifth metacarpal bone, and, above, the tendon is lifted from its groove in the ulna. The capsule is rather easily separated from the lower end of the ulna. The capsule is divided over the cuneiform, the joint between this bone and the pisiform is opened, and the tendon of the flexor carpi ulnaris is left intact. The hook of the unciform is now cut across, special care being taken to preserve the deep branch of the ulnar nerve, and the bundle of flexor tendons is easily displaced outward in one mass. The ligamentous attachments of the three inner metacarpals are divided on the palmar aspect, but the insertion of the flexor carpi radialis into the second metacarpal bone is preserved. The attachments of the capsule to the anterior border of the lower end of the radius are separated. The capsule is separated from the radius, in a similar manner, upon the dorsal aspect, special care being taken, when the radial side has been

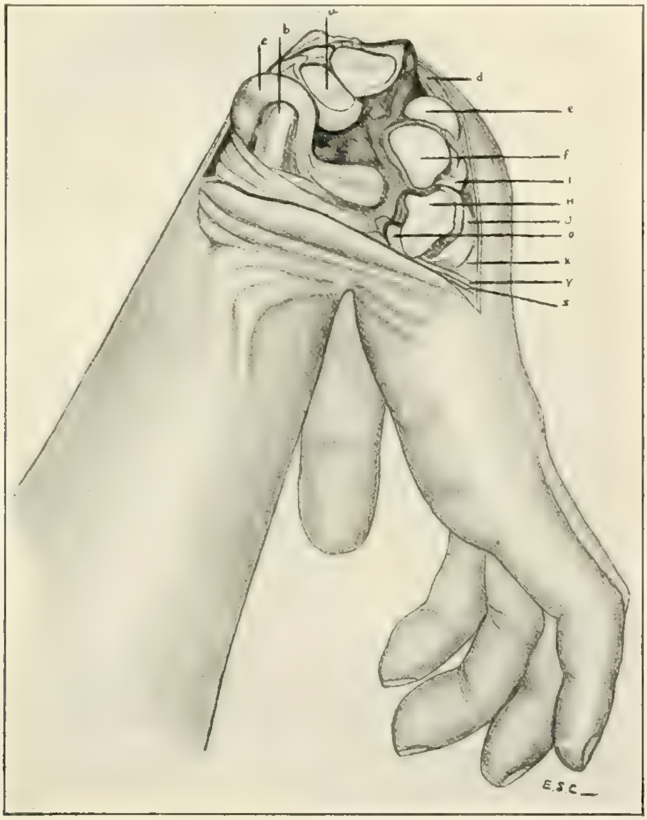


FIG. 230.—Excision of the Wrist by the Dorso-ulnar Incision; Second Stage. The wrist joint is dislocated and the posterior ligament is detached from the bones of the forearm. (After Kocher.) *a*, Radius; *b*, styloid process of ulna; *c*, ulna; *d*, tendon of the extensor minimi digiti; *e*, scaphoid; *f*, semilunar; *i*, os magnum; *h*, cuneiform; *j*, unciform; *o*, pisiform; *x*, fifth metacarpal; *y*, dorsal branch of the ulnar nerve; *z*, posterior ulnar vein.

reached, to lift all tendons from their grooves. The insertions of the tendons of the radial extensors are not detached from the dorsal aspect of the third and second metacarpal bones.

The hand is now forcibly dislocated toward the radial and palmar side, so that the thumb lies in contact with the radial border of the forearm. (Fig. 230.) It may be necessary to separate the capsule and periosteum still further from the radius. The carpal bones may now be dissected out with ease, and a thin layer is removed from the articular surfaces of the radius and ulna. Some difficulty may be encountered in removing the trapezoid and the bases of the three radial metacarpals, but this disadvantage is more than offset by the great functional advantage of preserving intact the radial extensors. When the disease involves this region mainly, and it is necessary to obtain a thorough exposure, the dorso-radial incision of Langenbeck (Fig. 231) may be used.

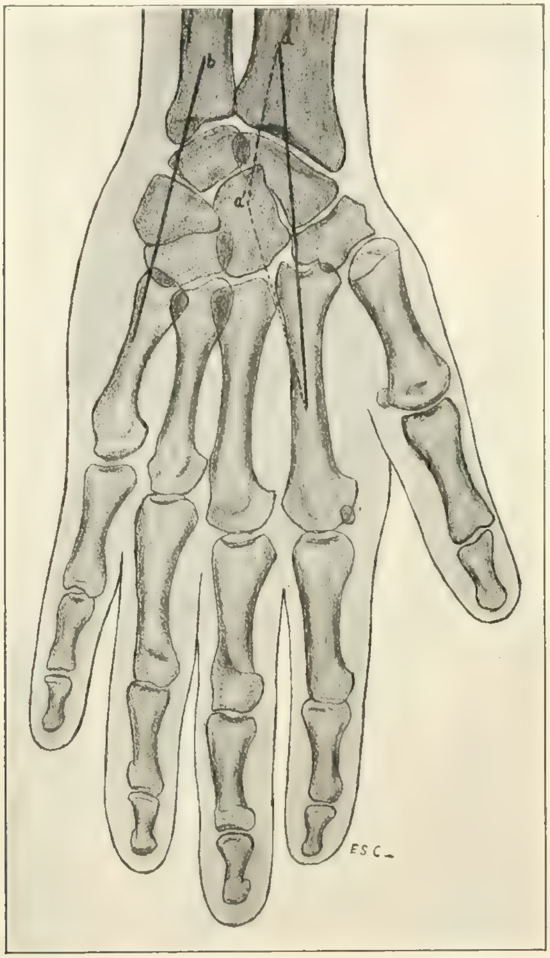


FIG. 231.—Excision of the Wrist. *a*, Langenbeck's incision; *aa'*, Ollier's radial incision.

The ends of the radius and ulna should be sawed in a curving direction, since rounded bone ends facilitate greatly the motions of dorsal and palmar flexion. The amount of bone excised will, of course, depend entirely upon the extent of the area diseased. The dissection and the excision of diseased soft tissues should be conducted in the same accurate and careful manner that is observed in the removal of a malignant tumor. The periosteum cannot be preserved in all places, and side extensions of disease or sinuses should be carefully excised.

Langenbeck resects through a straight dorso-radial incision, which begins over the middle of the second metacarpal bone and extends upward over the middle of the wrist and along the axis of the forearm to a point about one inch above the lower extremity of the radius. This incision strikes the interval between the tendons of the extensor communis digitorum and extensor indicis on the ulnar side, and the extensor longus and brevis pollicis on the radial side. The incision passes through the posterior annular ligament and down to the radius above, opens the joint, and extends downward on the base of the third metacarpal bone. The tendon insertions of the extensor carpi radialis brevior and longior are detached from the third and second metacarpal bones respectively, and the ends of these bones are exposed. The soft tissues are now retracted, the periosteum on the posterior surface of the lower end of the ulna is elevated in a similar manner, and all structures are drawn inward. The radio-carpal joint is now well exposed by flexing the wrist, and the first row of carpal bones may be removed, subperiosteally if possible. If necessary, the second row is removed in a similar manner. The remaining steps of the operation differ in no way from those already described.

Ollier recommends the use of two incisions for the purposes of excision, and a third for drainage only, and he describes the operation in two stages. The first stage deals with the dissection of the soft parts, and the second stage with the excision of bone.

First Stage.—The chief incision is made on the radial side of the dorsum: it begins over the middle of the second metacarpal bone and extends upward, in a somewhat curved course, along the radial border of the extensor indicis tendon to a point one inch and a half above the line of the radio-ulnar joint. The extensor indicis is exposed without opening its sheath, and retracted carefully toward the ulnar side. The incision is then carried down to the periosteum and dorsal ligaments, great care being taken not to injure the extensor carpi radialis brevior, and the attachment of this muscle to the base of the third metacarpal bone is separated. In the upper end of the incision the extensor longus pollicis will be encountered and should be drawn outward. This incision should be about four inches long. The ulnar incision is made along the radial border of the extensor carpi ulnaris; it begins over the base of the fifth metacarpal bone and ends at a point about one inch above the tip of the styloid process. The branch of the ulnar nerve which goes to the little finger crosses this line and should be avoided. This incision extends down to the cuneiform and unciform bones. A third incision, one inch long, over the styloid process of the radius, is recommended for drainage only; and this incision should be made at this stage of the operation, before the relations of the parts are disturbed.

Second Stage.—The second stage of the operation pertains to the removal of the bones. This part of the operation does not differ materially in technique from that already described. The trapezium may often be left, and the pisiform and unciform processes should always be left, even when the greater part of the articular ends of the bones have been removed.

Lord Lister's operation is also performed through a radial and an ulnar incision. The radial incision begins over the middle of the dorsal surface of the radius, on a level with the styloid process, and is directed toward the metacarpo-phalangeal joint of the thumb, in a line parallel to the course of the tendon of the extensor longus pollicis muscle. At the radial border of the second metacarpal bone the line of incision becomes vertical and is continued as far as the middle of this bone. The merit of this incision rests on the fact that it does not imperil the safety of the radial artery, even in the presence of marked inflammatory thickening. The tendons of the extensor carpi radialis longior and brevior are next detached with a knife, and the extensor longus pollicis, with the radial artery and other soft structures, is drawn outward. The trapezium is next separated from the rest of the wrist by cutting forceps, applied along the line of incision; but the bone is not removed until later. The wrist is now bent backward in order to relax the extensor tendons, and the straight ulnar incision is made. This incision is made on the palmar surface; it begins two inches below the lower end of the ulna, on its anterior surface, and is carried downward between this bone and the flexor carpi ulnaris to the middle of the palmar aspect of the fifth metacarpal bone. The tissues posterior to this incision are then retracted; the tendon of the extensor carpi ulnaris is separated at its insertion and lifted out from its groove in the ulna; and the tendons of the extensors of the fingers and the posterior and internal lateral ligaments are separated from the carpus. The palmar surface is now carefully dissected close to the bone. After the dissection of the carpus has been completed, the bones are extracted through the ulnar incision. The articular ends of the radius and the ulna are likewise made to protrude from the same incision, and their articular ends are sawed off. The ulna is sawed obliquely in such a manner as to remove that portion which articulates with the radius, and a thin slice only is removed from the radius if the bone is not seriously damaged. It adds greatly to the symmetry and stability of the hand to leave the radius and the ulna of the same length. As has already been stated, stability will likewise be given by leaving all, or at least some portion, of the styloid processes.

The Immediate Treatment of the Wound, and the After-treatment.—After the completion of any one of the operations described above, the tourniquet should be removed and all bleeding vessels carefully secured. Special attention is then given to thorough drainage, and the incisions are closed by suture, except at the points of drainage. Aseptic dressings are applied in such a manner that it will be easy to dress the wound subsequently without disturbing the splint, and a fixation apparatus is applied. Many forms of splint have been suggested, but the author has found uniform satisfaction from the use of plaster of Paris, applied either as a strap splint, made from superimposed layers of an ordinary plaster bandage, or as an interrupted encasing splint, reinforced by arched metal bars. Fig. 232 illustrates the strap-splint method. If the dressings are thoughtfully applied, the palmar splint may remain in place for a long period of time, particularly when dorsal incisions are used. Whatever splint is used, it should end at the metacarpo-phalangeal articulation, in order to give free motion to the joints of the thumb and fingers, and it should permit of a position midway between pronation and supination, with the hand slightly extended and abducted. The frequency with which the dressings should be renewed depends entirely upon the primary cleanliness of the joint; but, as a rule, they should be changed every second day after the first week. Two days after operation, both passive and active motion should be encouraged in the phalangeal and the metacarpo-phalangeal joints; and, at the end of ten days or two weeks, careful passive motion should be made in the wrist. During the early treatment the thumb and index finger should be kept apart. The ultimate result will depend very largely upon the persistence with which active

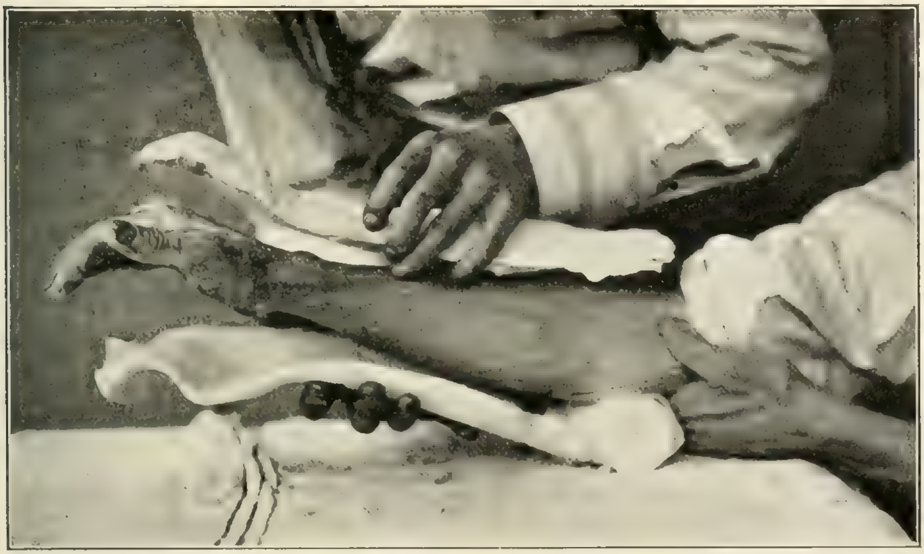


Fig. 232.—Method of Applying Anterior and Posterior Plaster-of-Paris Strap Splint. (Original.)

and passive movements, massage, electricity, and gymnastic exercises are carried out. The continued interest of the surgeon and the untiring aid of the patient for a period of from six to nine months will be required if the best results are to be obtained. Satisfactory movements of the fingers may be expected early, and flexion and abduction and adduction of the wrist will be very largely restored. Extension of the fingers and extension of the wrist are the most difficult movements to recover.

Resection of the Metacarpal and Phalangeal Bones and Their Joints.—Resection is not frequently indicated in this region, and the bones are so accessible that a detailed account of various operative methods is not deemed necessary. Tuberculosis of the bones will present almost the sole indication for resection of the metacarpal bones, while septic infection is the only lesion that will demand excision of the joints.

The metacarpal bones are removed through a dorsal longitudinal incision. The tendons and soft parts are pushed to one side, and a subperiosteal excision is performed if possible. The importance of preserving the bases of the metacarpal bones will be apparent when it is remembered that the carpo-metacarpal joint of the thumb is the only one with a separate synovial membrane. The corresponding finger will recede upward after the metacarpal has been removed; but it will usually retain its power and should be left in working people.

The phalanges are excised through two lateral incisions, which carefully avoid the arteries and nerves. Lateral deformity is particularly to be feared, but can usually be avoided by the bilateral incision and by the prolonged use of a supporting splint.

Resection of the metacarpo-phalangeal and phalangeal joints will be indicated for the cure of septic arthritis. The joint is exposed by lateral incisions which should be ample in length and should give free exposure of the bone ends. For the metacarpo-phalangeal joints the incision should be one inch and a half long, and for the phalangeal joints not less than one inch long. The joint should be thoroughly cleaned out, all diseased bone removed, and the cavity firmly packed. Whenever possible, one articular surface should be left.

A very satisfactory degree of motion will be regained in a large number of cases when the after-treatment is carefully followed.

Excision of the Hip.—Excision of the hip is an operation which is much less frequently performed to-day than a few years ago. This has been brought about by the very complete demonstration, from a large number of cases, that the average result from the conservative treatment of tuberculosis of the hip is better than that obtained by operative treatment. This statement should not be taken to imply, however, that the operation of excision should never be done for tuberculous disease. It means that every incipient case of tuberculous disease of the hip should be first treated by the most approved methods of immobilization, diet, and hygiene. If, however, the condition does not improve satisfactorily under such a course of treatment; if there are evidences of active suppuration and rapid disintegration of the joint; and if repeated *x*-ray examinations reveal a progressive destruction of either the head of the bone or the acetabulum, or both, then excision should be done. The disease may take this course, either because of an infection of unusual virulence, or because of total inability on the part of the poor to command the conditions essential to a conservative plan of treatment.

It is quite evident that very careful observations will be required to enable one to arrive at this decision, and special attention is called to the value of the *x*-ray in the hands of an expert, as an instrument of precision in this regard. Lovett was able to report that in ninety-five out of one hundred cases the opinion formed by means of the *x*-ray as to the presence and stage of the disease was borne out clinically. Freiberg reports equally good results. This method will not only show extension of caseation and suppuration and enable the surgeon to apply the operative treatment at the proper time, but it will greatly increase the scope of the early operative treatment of extra-articular foci.

In a certain class of patients, fortunately rare, the early symptoms of a tuberculous infection are so rapid in their development, the swelling and the tenderness increase so rapidly and so persistently, in spite of immobilization, and the general symptoms are so marked, that there seems great danger of a generalization of the infection. Excision should be done at once in this class of cases.

The mortality from excision of the hip for tuberculosis was once fifty per cent, and the functional results were not always good; yet it must be remembered that the operation has most frequently been done only in the very bad cases, which would yield a mortality of seventy-five per cent if not operated upon. The bad cases cannot yield the best results, because of the extensive removal of tissue that becomes necessary in such cases.

Ankylosis after tuberculosis or from other causes is not looked upon as an indication for excision. This condition may be overcome by subtrochanteric osteotomy.

Gunshot injury of the hip joint is not an indication for immediate resection; but this operation should be very promptly done for purposes of drainage, when it has been clearly demonstrated that ordinary incision will not suffice. (See article on Gunshot Wounds in Vol. II.)

Morbus coxæ senilis will call for excision only when ankylosis or very deficient mobility has resulted after the ordinary methods of treatment.

Suppurative disease of the hip which does not yield to the ordinary treatment by efficient drainage, should be treated by excision. When diseased bone is discovered at the time of making incisions for drainage, this should be removed; or, if the acetabulum is found to be extensively diseased, excision should be done at once.

Separation of the epiphysis of the femur may occur under twenty years of age and will furnish an indication for the removal of the head of the bone.

Jacobson summarizes the indications for excision of the hip by a quotation from the report of the Clinical Society's Committee on Excision of the Hip. They are as follows:

(1) Necrosis and separation of the entire head of the femur and its conversion into a loose sequestrum.

(2) The presence of a firm sequestrum either in the head or neck of the femur, or in the acetabulum.

(3) Extensive caries of the femur or the pelvis, leading to prolonged suppuration and the formation of sinuses.

(4) Intrapelvic abscess following disease of the acetabulum.

(5) Extensive and old-standing synovial disease, and ulceration of the cartilages, with persistent suppuration.

(6) Displacement of the head of the femur on the dorsum ilii, with chronic sinuses and deformity.

Before discussing the operative treatment of tuberculosis of the hip joint the term "good result" should be defined.

A good result in tuberculous hip disease is one with a minimum amount of shortening, without deformity, and with the maximum range of motion. Almost a perfect restoration of function, with no trace of deformity, may be obtained in those cases in which the well-recognized methods of treatment are begun very early. A less satisfactory, yet at the same time a relatively good, result will be obtained when the bony structures become more extensively diseased in the second stage; but, in the third stage, we must be satisfied with merely a correction of deformity and an arrest of the disease. As has already been stated, the average result from excision will not be as good as that obtained by conservative means, and the result will suffer still further by comparison, since the operation of excision is now done only in those cases which do badly under this plan of treatment. A good result after excision, as determined by shortening, deformity, range of motion, and stability, will depend very largely upon the amount of bone removed. If too much of the bony tissue is removed, a flail joint results; if the periosteum is needlessly excised, corresponding shortening will probably occur.

Anatomical Considerations.—In addition to the well-known anatomical facts which relate to the hip joint, special attention is called to the following facts: (1) The head of the femur and the acetabulum are cancellous in structure and quite vascular. (2) The acetabulum is lined at all points with cartilage, except at the U-shaped fossa at the bottom of the acetabulum, to a certain part of which is attached the ligamentum teres. (3) Shortening can occur only from failure in development or an actual loss of substance of the bony structure. (4) The arrangement of the periosteum and the points of insertion of the ligaments and the muscles should be carefully considered, since the functional result will depend very largely upon the preservation of the periosteum. When practicable, the greater trochanter should be chiselled off with its muscular insertions, and sutured back in place after the excision has been completed.

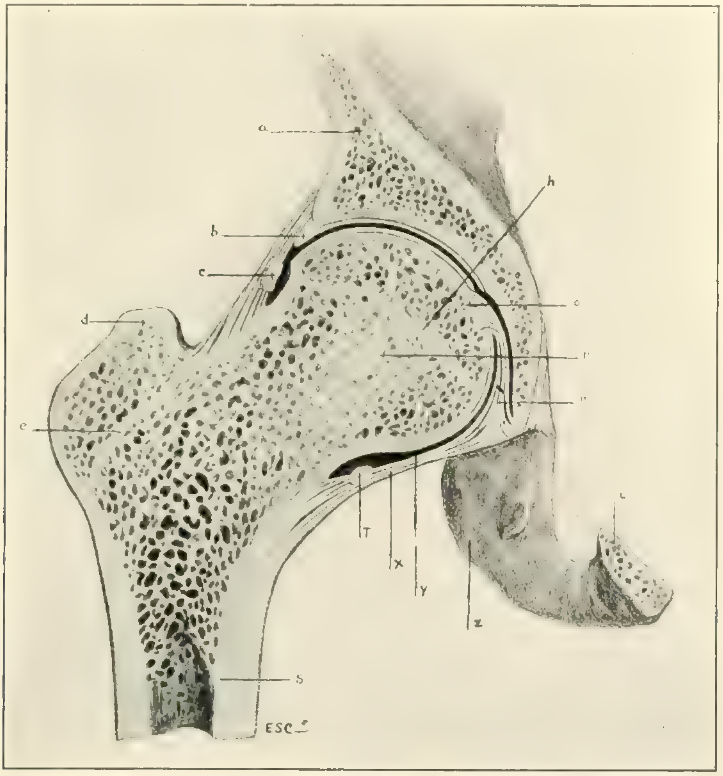


Fig. 233.—Right Hip Joint shown in Frontal Section. Posterior half of section viewed from in front. (After Spalteholz.) *a*, Ilium; *b*, cotyloid ligament; *c*, orbicular zone of capsule; *d*, great trochanter; *e*, epiphyseal junction; *s*, shaft of femur; *t*, orbicular zone; *x*, capsule of joint; *y*, cavity of joint; *z*, tuberosity of ischium; *l*, inferior ramus of ischium; *z*, ligamentum teres; *h*, epiphyseal junction.

Operation.—A radical and a conservative method of operating are described. In the radical method no effort is made to preserve the periosteum, while, in the conservative method, the most careful attention is directed to the preservation of this important structure. Even in tuberculous cases it is usually possible to preserve a part of the periosteum, and the operation should be modified to meet the requirements of the anatomical conditions encountered at the time of operation.

There have been recommended a variety of incisions, which may be divided into the posterior and the anterior.

Resection by Posterior Incision.—Resection of the hip was first performed by White, in 1821, through a posterior curved incision, and this incision has not been materially improved up to the present time (*c*, Fig. 234).

This incision is made with the patient lying on the healthy side; it begins at a point midway between the anterior superior spine of the ilium and the greater trochanter, passes backward over the most prominent point of the upper border of the trochanter, and then follows its posterior border downward for three or four inches. The incision is carried down to the muscles and periosteum, and the flap thus formed is dissected downward sufficiently to expose the base of the trochanter. The periosteum is transversely divided at the base of the trochanter, the trochanter is chiselled away with its attached muscles, and this deeper flap, including the trochanter and muscles, is dissected upward to expose freely the neck and head of the femur. The capsule is now divided longitudinally *in situ*, and the neck of the femur is divided with a chisel at a

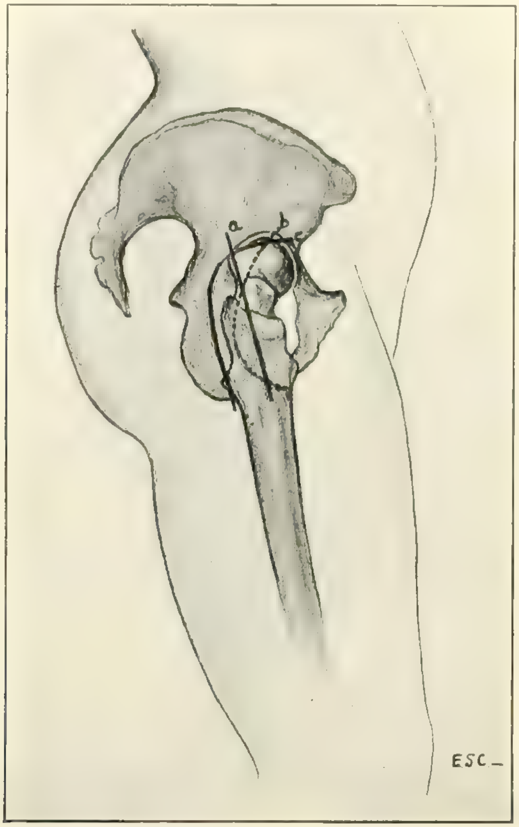


Fig. 234.—Excision of the Hip Joint. *a*, Langenbeck's incision; *b*, Sayre's incision; *c*, White's posterior curved incision.

point to be determined by the extent of the disease. (Fig. 235.) The head of the bone is extracted with bone-forceps. The ligamentum teres is usually destroyed. This plan of removing the head of the femur is much to be preferred to that of dislocating the head by adducting the limb, then sawing it off. The latter plan injures the tissues very much more than the former, and subjects the patient to the dangers of fracture of the femur or of separation of the lower epiphysis.

The question of the site of bone section is one upon which surgeons differ. Preservation of the greater trochanter with its attached muscles will undoubtedly yield very much better motion and greater stability than division of the bone at the base of the trochanter; yet Jacobson maintains that, after healing, the process becomes strongly drawn upward against the scar and constantly irritates it. He believes that this disadvantage far outweighs the advantage of greater mobility and more rapid healing.

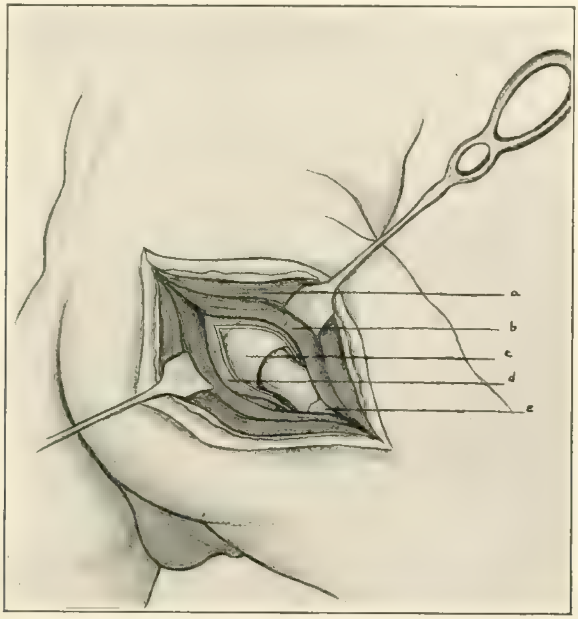


FIG. 235.—Excision of the Hip Joint by Posterior Incision. (After Lejars.) *a*, Gluteus maximus muscle drawn aside; *b*, Gluteus medius; *c*, head of femur; *d*, capsule of joint; *e*, great trochanter.

If it be determined that this lower division of the bone is necessary or desirable, the primary incision should be carried down through the periosteum along the posterior border of the trochanter, and the muscle attachments to this structure should be elevated, if possible, in a single piece. The capsule and the periosteum of the neck are now divided as before and separated in a careful manner from the bone. The bone is divided just below the top of the trochanter with an osteotome or a Gigli saw.

Langenbeck exposes the joint by a straight longitudinal incision, five or six inches long, made directly over the great trochanter and extending upward toward the posterior superior spine of the ilium. (Fig. 234.) The operation is continued subperiosteally, as described above.

Kocher makes a curved incision extending from the base of the greater trochanter upward to its anterior superior angle, thence upward and outward toward the median line in the direction of the fibres of the gluteus maximus. The deep dissection is then continued with a view to the preservation of the nerve supply of all muscles in the region. This dissection is described as follows by Kocher: "The dense aponeurotic insertion of the gluteus maximus is now divided upon the outer aspect of the trochanter, exposing the periosteum and the insertion of the gluteus medius, which covers the whole of the upper border, the detachment of the gluteus maximus being thus facilitated. The upper and back part of the incision divides the fibres of the gluteus maximus, and generally some vessels of considerable size, which must be ligated. When possible, a still better plan is to expose the upper border of the gluteus maximus and to retract it downward.

"A fatty layer now appears, and, after it has been divided, the interval is reached between the lower border of the gluteus medius and minimus above and the pyriformis below. This space is opened up, and the broad tendon of insertion of the gluteus medius, and under it the tendon of the gluteus minimus, together with the periosteum, are incised down to the anterior intertrochanteric line and detached forward." The remainder of the operation is conducted subperiosteally, as has already been described.

Sprengel describes an incision which may be used when it is necessary to get a more extensive view of the posterior part of the pelvis or to resect a portion of the ilium. This incision is made along the iliac crest from the posterior superior spine to the anterior superior spine, then descends along the posterior border to the tensor fasciæ femoris. This large flap of skin, including all gluteal muscles and the periosteum, is turned downward and backward and the joint freely exposed.

Resection by Anterior Incision.—Hueter, Barker, Luecke, and Schede have recommended resection of the hip by anterior incision (Fig. 236). The chief reasons given for this preference are, slight interference with the muscles and greater ease in treating the wound during convalescence.

Barker makes an incision, three or four inches long, which begins an inch below the anterior superior spine and extends downward and inward in the interval between the tensor vaginæ femoris and glutei on one side, and the sartorius and rectus on the other. The neck of the bone is exposed at once. The muscles are strongly retracted and the bone is divided at a point and in a manner to be determined by the consideration, as already stated, of the pathological condition of the parts.

After the joint has been exposed and the head of the bone removed, the remainder of the operation is conducted in a manner which is practically uniform with all operators. When the operation is performed for tuberculosis, the most careful sharp dissection should be made for the removal of all suspicious tissue, and any foci of disease in the femur or acetabulum should be carefully removed. The necessity for preserving the periosteum, even in fragments, must be remembered, and the periosteum of the neck of the bone should be attached to the periosteum at the lower border of the acetabulum, wherever this is possible. All hemorrhage should be accurately controlled, the muscles should be sutured over the periosteum, and the wound closed with abundant drainage; or, when the operation is done for tuberculosis, the cavity should be thoroughly mopped with pure carbolic acid, and afterward with ninety-six-per-cent alcohol, before the wound is closed. Most surgeons recommend a voluminous tamponade of the cavity with iodoform gauze and treatment of the wound without suture. This will be quite essential when the joint has been the seat of a mixed infection; but drainage will not be needed in the aseptic cases, unless it be for a very brief period of time to take care of serous exudation. When the greater trochanter has been chiselled off, it should be sutured back in place, and a drainage tube should be placed behind, in order that there may be no opportunity for retention of secretions. When the muscle insertions alone have been elevated from the greater trochanter, and the tro-

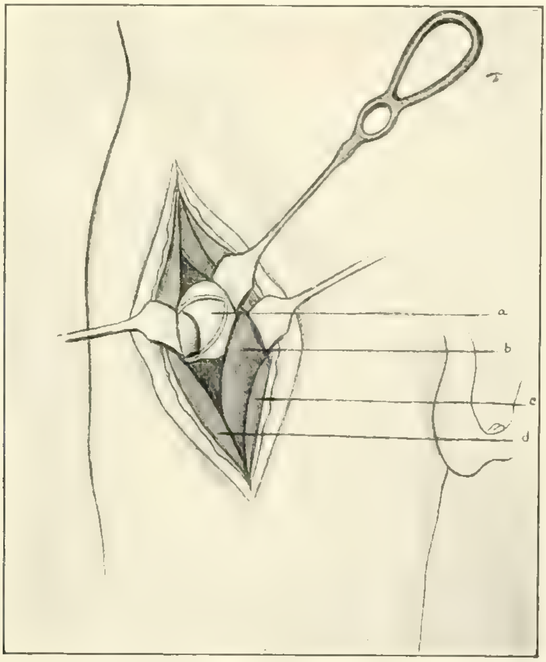


Fig. 236.—Excision of the Hip Joint by Anterior Incision. (After Lejars.) *a*, Head of femur; *b*, iliopsoas muscle; *c*, sartorius muscle drawn inward; *d*, anterior rectus muscle.

chanter removed, an effort should be made to give them a firm mooring by suture. After the dressing of the wound has been completed the hip should be immobilized either with a long lateral board or with a spica plaster-of-Paris splint, and extension should be applied. A weight of from ten to twenty pounds, according to the age of the patient, should be used for this extension.

The wound should be allowed to heal by granulation. The patient may be allowed to sit up in bed at the end of two weeks, but the extension should be kept up for six months. After a period of six weeks the extension is to be maintained with a Thomas splint, and the patient allowed to get about. He should not be allowed to walk without support for six months.

A tendency to stiffness in the joint should not be too vigorously combated, since a hip ankylosed in a position of slight flexion and abduction will be very useful. It has been quite well demonstrated, from a number of specimens, that the head of the bone may be satisfactorily reformed after subperiosteal resection, and that this new head may be even covered with cartilaginous structures.

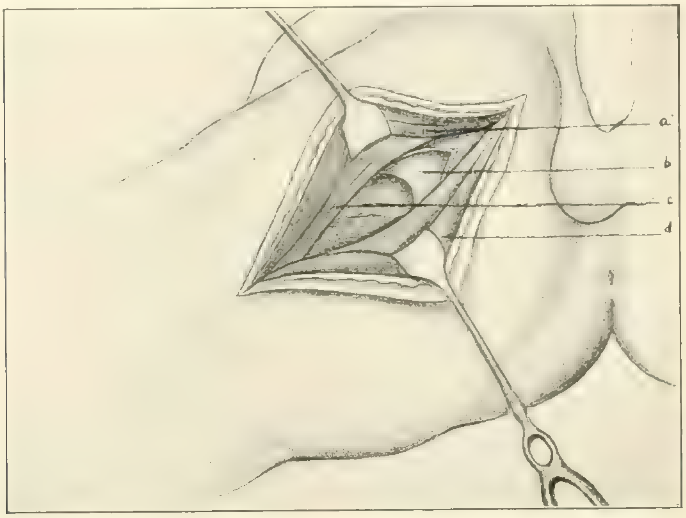


Fig. 237.—Excision of Hip Joint by Internal Incision. (After Lejars.) *a*, Internal rectus muscle drawn aside; *b*, head of femur; *c*, adductor magnus muscle.

The possibilities of obtaining a useful joint after excision have been so greatly improved by the introduction of arthroplastic methods that the indications for the operation have been materially modified. Excision for ankylosis, an operation which formerly was considered to be in many instances unjustifiable, has now become a justifiable procedure which frequently gives excellent results.

Excision of the Innominate Bone.—This operation has been successfully performed a few times for the removal of tumors. An excision done for this purpose will of necessity be atypical in nature, and both the incision and the deeper dissection will in every instance be planned to meet the requirements of the individual case. In one case reported by Kocher, the operation was done for a large osteo-chondro-sarcoma of the ilium. In this instance the pubic bone and ischium were sawed through at a point 2 cm. (about $\frac{4}{5}$ inch) internal to the acetabulum, and the ischium was separated from the sacrum at the sacro-iliac joint. The upper end of the femur was also resected. Four years later this patient was living and able to do light agricultural work.

When a tumor growth is confined to the crest of the ilium only a corresponding resection of the bone will be needed. The incision recommended by Sprengel for exposure of the hip joint, or a modification of this incision, will be well adapted to most cases of excision of the innominate bone.

Excision of the Coccyx.—Excision of the coccyx is done for coccygodynia and for fracture of the coccyx. The operation is simple and exposes the patient to no dangers. The patient is placed on one side and a longitudinal incision is made down to the bone. The lateral connections of the bone are first divided, the bone is then seized with bone forceps, and enucleation is completed. Hemorrhage is accurately arrested and the wound closed without drainage.

Excision of the Knee Joint.—Indications.—Excision of the knee is indicated in the following conditions: (1) tuberculosis; (2) suppurative arthritis that has not yielded to drainage; (3) osteoarthritis; (4) ankylosis; (5) old, neglected infantile paralysis; and (6) injury from gunshot wound and other causes.

(1) Tuberculosis of the knee undoubtedly furnishes the most frequent indication for excision of this joint; yet it should at the same time be stated that a very great difference of opinion prevails as to the precise application and limitations of the method. With the advent of aseptic surgery, tuberculous joints were attacked with great frequency; but a positive reaction followed the reports of statistics that showed results less satisfactory than those collected for the conservative treatment; and the operation has been much less frequently performed during the past decade. At the present time we find an increasing tendency to return to an operation which completely removes all diseased tissue, and restores a patient to health in a much shorter period than is possible under the most favorable conditions of rest and environment. This general change in attitude toward the procedure, and more especially the difference in opinion regarding the choice of method to be applied in any given case, call for a consideration of the questions involved. The first question that arises pertains to the primary danger of the operation and the danger of incomplete removal of all diseased tissue. The primary danger of such an operation, done under a perfect aseptic technique, is very slight in properly selected cases. Then again, the danger that tuberculous material may be left

behind has been so greatly reduced by the development of a technique which devotes itself to a most rigid and accurate removal of all tuberculous tissue in and about the joint, that the probabilities of complete eradication of the disease have been greatly improved. This conclusion seems so well founded that the author believes that statistics regarding recurrence, which have been based upon cases treated by previous methods of excision, cannot be given a decisive value in the argument. As a matter of fact, many of the operations forming the basis of such statistics have not been complete, and many of the recurrences which are reported would not have taken place if an accurate and thorough dissection of the joint had been made. A curette which at first has a sharp edge very soon becomes a dull curette, and, even when sharp, it is very likely either to leave tuberculous material behind or to crush tubercle bacilli into uninvaded tissues that are left. The use of sharp knives for both the soft tissues and the bone will obviate to a large degree this danger of recurrence.

It may therefore be stated that both the primary dangers of the operation and the dangers of recurrence have been so greatly reduced by sharp dissection that neither furnish serious counter-indications.

The age of the patient is a factor of importance in the decision. Young states that "excision is an operation to be performed only in adult life when we wish to obtain bony ankylosis and wish to avoid the long tedious disability incident to conservative treatment. It is practically never performed during childhood, on account of the great shortening which results from removal of the epiphyses." The importance of preserving the epiphysis in all cases is apparent, and particularly before the age of fifteen. A consideration of the epiphysis at the knee possesses special importance, since the lower epiphysis of the femur and the upper epiphysis of the tibia are the chief points of growth in these bones. This one point, therefore, will lead us to choose the non-operative course as a rule in children; yet many cases will arise which demand operative treatment, and it is important to remember that such operative treatment may be applied without serious disturbance of the epiphyseal line. Arthrectomy and atypical excision have therefore largely replaced typical excision in children. The dictum remains, however, that children should be treated, as a rule, by non-operative means.

The social rank of the patient has become almost the controlling factor in deciding as to the propriety of excising the knee—a fact which is briefly and forcibly expressed by Jacobson when he says: "Excision of the knee being almost unknown in private practice, it is needless to remark that this account of the operation refers almost entirely to hospital patients." The well-to-do will usually obtain a very early diagnosis, they can command time, diet, and environment, and a tuberculous lesion will rarely, in this class of patients, go on to the destructive stage which demands operation. With the financially less fortunate, however, it is an entirely different story. The poor patient can ill afford to lose two or three months, much less as many years, away from work, and, if the patient is a child of poor parents, the requirements of the case are to a like degree inaccessible. Such patients pass from clinic to clinic, or from one physician to another, are treated by badly fitting splints or apparatus, never have the advantages of diet or suitable climate, and are required to be on their feet far too great a part of the time. Under these conditions the patient is sometimes fortunate enough to secure an arrest in the process or even a cure, yet the chances are very much more in favor of continued progress of the disease, with destruction of the important joint elements, repeated recurrences of acute trouble in a quiescent joint, or a generalization of the infection. An excision or an erasion done at an early stage in such patients will reduce the period of treatment to as many months as would otherwise have been required in years. It subjects the patient to but slightly increased risk and gives good promise of complete cure and a valuable extremity. The very best advice that can be given to a poor patient would therefore seem to be a preliminary period of a few weeks or months of immobilization; and, if such treatment is clearly impracticable, or if definite improvement is not noted, excision or erasion should be done. The following opinion of Mr. Howse regarding the stage of the disease at which excision should be done will be of value in the decision. This operation may be done in the following classes of cases: "(1) Cases in which the disease has advanced so far as to cause flaking of the articular cartilage or grating in the movement of the joint, whether suppuration be present or no. (2) Cases in which backward displacement of the tibia has taken place. (3) All cases of over six months' duration, in which there is reason to believe that the disease has started in an epiphyseal ostitis. (4) Cases of extensive suppuration in the joint starting from pulpy mischief. (5) Cases in which the pulpy infiltration of the synovial membrane has advanced to any considerable degree over the articular cartilage. (6) Cases in which pulpy infiltration has extended beyond the capsular ligament to the crucial ligaments and semilunar cartilages." It may be further stated that a very rapidly developing case, or a case in which a non-operative course results in neither local nor constitutional improvement, will likewise demand operation.

(1) The decision does not always lie between excision and the expectant treatment, since the question of amputation may intrude. Amputation should be entertained when extensive infiltration and disorganization of the soft tissues of the region have taken place and when the bone is clearly diseased for a considerable distance above or below the joint. Great debility of the patient, extensive pulmonary involvement, or simultaneous involvement of many joints may likewise call for amputation; yet bone or joint disease elsewhere, while not prohibiting amputation or multiple excision, should, for apparent reasons, lead to a very careful consideration of all the aspects of the question. If the

condition of the patient permits, consecutive resections should be performed. The existence of a slight or moderate pulmonary lesion is not a counter-indication to excision.

A final point to be considered in the decision for or against excision is the future value of the limb. This can be very briefly discussed by stating that after excision of the knee, with good recovery, a patient can not only walk without other support, but he can often walk as far and as well as before the operation. The degree of limping will depend entirely upon the shortening, and it is remarkable to note how entirely some patients with slight shortening succeed in hiding a limp. The manufacturers of artificial limbs have developed excellent substitutes for amputated lower limbs, yet an apparatus of this sort does not commonly compare in usefulness and desirability with a much shortened leg and foot. The patient is usually better satisfied, often more agile, and perhaps, most important of all, he is not dependent upon an instrument maker.

(2) In suppuration of the knee joint prompt and efficient drainage will usually result in a cure, yet cases will be encountered in which the general symptoms do not abate and the joint shows signs of disorganization and caries. In such cases complete excision may be required. Such conditions are sequels of pyæmia, infective arthritis, etc.

(3) In severe osteo-arthritis involving one knee and occurring in patients under forty years of age, a typical excision should give a very useful limb. When possible, however, an atypical excision should be made as a part of an arthroplastic operation undertaken for the purpose of restoring a limited motion to the joint.

(4) Bony ankylosis of the knee usually occurs in a flexed position and requires some operation which will place the limb in a better weight-bearing position. Authorities are not in accord as to the best method of treating the condition. Complete excision, osteotomy at or above the point of ankylosis, and arthroplasty are the measures to be considered. Complete excision involves the removal of a sufficient wedge of bone to place the leg in either a perfect line with the axis of the femur or questionably at a very slight angle of flexion. Care should be taken to remove sufficient bone to permit of easy extension without tension on the soft tissues that lie behind the joint. A wedge of bone sufficiently large to accomplish this will almost certainly invade the epiphyses in children. Jacobson advises strongly against excision and recommends either division of the line of bony union with an osteotome, first from one side then from the other, or, in cases where the soft parts are strongly contracted, a double osteotomy of the femur and of the tibia. This is advised as a very much less extensive operation than excision and very much less likely to result in subsequent interference with the growth of the limb. Arthroplasty is the ideal operation (see page 372) and should be performed whenever practicable.

(5) In certain cases of old neglected infantile paralysis of a lower extremity, particularly in those who are too poor to command suitable apparatus, an excision of the knee, which removes only a very thin slice from both the femur and the tibia, will greatly improve the value of flail limbs. The ankle joint should be excised first, then the knee. The stability of the apposition of the divided surfaces will be greatly aided by wiring the bones together.

(6) Gunshot wounds and injuries from other causes may furnish a positive indication for excision. The decision is difficult in these cases and will depend upon the special conditions encountered. From the early dictum, which demanded primary amputation for every gunshot wound of the knee, surgical opinion has now passed to the opposite extreme, particularly in military practice. (See article on Gunshot Wounds, in Vol. II.) When the bone is primarily seriously splintered and fragments of some size are broken off, a primary typical resection with drainage should be done. When suppuration supervenes, in the course of a conservative plan of treatment, and seems to extend in spite of irrigation and drainage, a typical excision should be done for the purpose of securing good drainage.

The same reasoning should be followed with cases of compound fracture of the knee.

Anatomical Factors.—Here, as in other joints, the success of the operation will depend upon an accurate knowledge of the anatomy. There is no point in the anatomy of the joint which equals in importance the epiphyseal lines of the femur and tibia. These two lines represent the chief points of development in each bone, and their close proximity to the joint surfaces brings them at all times within the danger line in excision. Their location is well shown in Fig. 238 (a skiagram redrawn). Bryant states that in a child of eight years of age no more than two-fifths of an inch can be removed from the tibia, nor more than three-fifths of an inch from the femur, without interfering with the epiphyseal lines.

The arrangement of the ligaments of the knee is so well shown in Figs. 239 and 240 that a detailed description in unnecessary; yet it seems wise to call attention to the functional importance of the anterior, the posterior, and the crucial ligaments. The great importance of anterior support and the power of extension is well illustrated by the disability which follows fracture of the patella. During extension the tendon of the quadriceps extensor, the sesamoid patella, and the ligamentum patellæ furnish the main anterior support of the knee; yet they are not the sole anterior support, as is sometimes shown by the fact that the reunion, by suture of the patella, does not give a complete result. The lateral expansion of the quadriceps often requires repairs. This point should be borne in mind in operations upon the knee joint. If, however, in this repair much shortening be caused by the lateral expansion, subsequent flexion is hindered for a time at least. The posterior ligament is likewise very strong and it is essential that the ligament should be left to inhibit overextension. Its destruction by disease may furnish an indication for complete resection. The crucial ligaments have a corresponding significance as regards stability and subsequent motion, and are shown in Fig. 239. The synovial membrane of the joint presents such unique irregularities, and side pockets are so numerous, that a very careful study of its arrangement is necessary. Fig. 241 shows with great clearness the facts of importance in this respect. It is apparent at a glance that such a degree of synovial expansion presents unusual difficulties both in drainage and as regards the complete removal of diseased synovial membrane. The dependent posterior portion of the cavity very evidently cannot be drained by tubes placed beneath the patella. The bursa of the popliteus muscle communicates with the joint and sometimes likewise with the superior tibio-fibular articulation. This fact imposes upon the surgeon unusual care in operative interference with the latter articulation The size and position of the quadriceps bursa present considerable variation, both in different individuals and in different positions of the

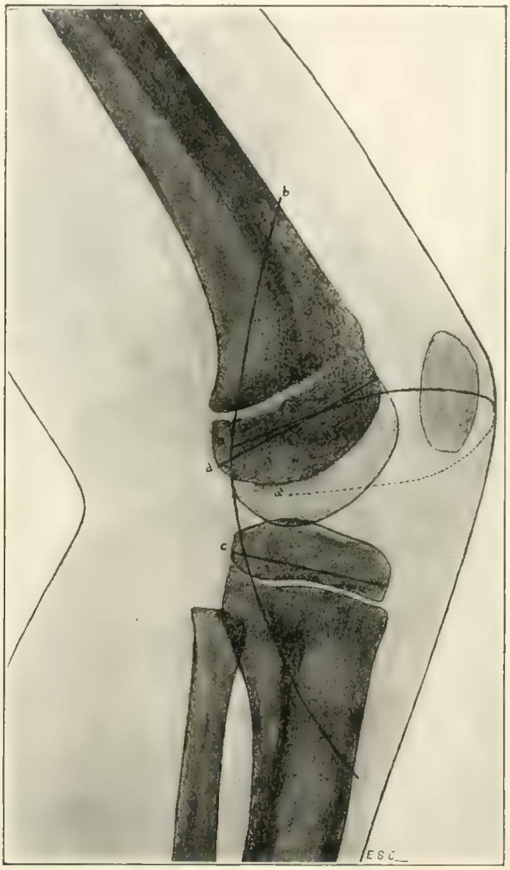


Fig. 238.—Resection of Knee, Showing Epiphyses. (Skiagram redrawn.) *aa'*, Transverse incision through the patella, from condyle to condyle; *b*, Langenbeck's incision; *c* and *d*, sites of bone section.

limb. It reaches its highest point in a position of extension, while in marked flexion it extends very little above a line marking the anterior limit of the articular cartilage of the femur.

The position of articular and muscular structures in the region of the joint is of evident importance. The popliteal vessels lie so closely in contact with the posterior ligaments of the knee joint that the location of the artery in particular should be considered whenever tuberculous infiltration of the ligamentous structures demands their removal. This danger is greatly increased in the presence of deformity, and in such cases the dissection should be done without a tourniquet, in order that the dissection may be aided by evidences of pulsation of the vessel. The articular arteries should be avoided because of the annoyance of hemorrhage. The superior internal and external arteries pass above the respective condyles of the femur. The inferior internal artery passes below the tuberosity of the tibia and beneath the internal lateral ligament, while the inferior external artery passes directly over the head of the fibula and likewise beneath the external lateral ligament.

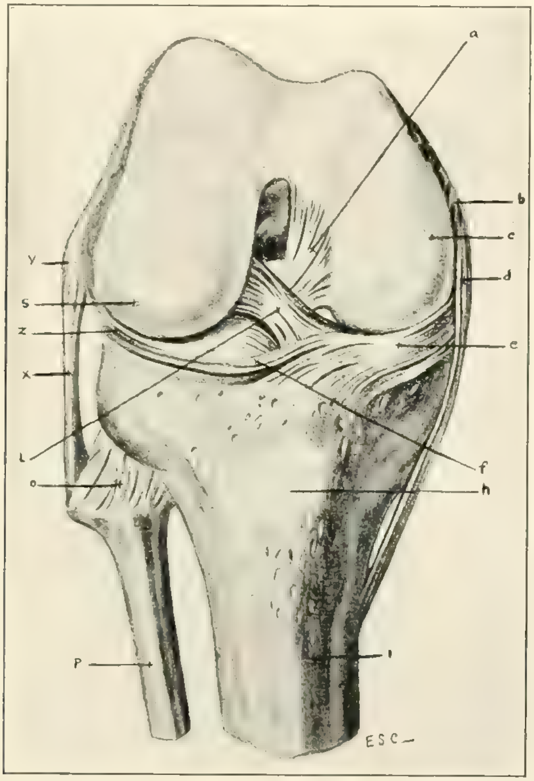


FIG. 239.—Right Knee as Seen from in Front. (After Spalteholz.) *a*, Posterior crucial ligament; *b*, inner epicondyle; *c*, inner condyle of femur; *d*, lateral tibial ligament; *e*, inner meniscus; *f*, transverse ligament; *h*, tuberosity of tibia; *i*, shaft of tibia; *p*, shaft of fibula; *o*, ligament of head of fibula; *l*, anterior crucial ligament; *x*, lateral fibular ligament; *z*, lateral meniscus; *s*, outer condyle of femur; *y*, outer epicondyle.

Operative Methods.—*The Operation of Non-subperiosteal Excision.*—The extremity is elevated for a few minutes to permit of venous outflow, and a tourniquet is then applied. The knee is now flexed to a right angle with the foot on the table, and any one of three incisions may be used to expose the joint. The writer prefers an incision which begins just over and posterior to the inner condyle and extends directly across the middle of the patella to a corresponding point on the opposite side (*aa′*, Fig. 238). This incision divides the skin and subcutaneous tissue. The lateral expansion of the quadriceps tendon is now divided along the same line, thus opening the joint, first on one side, in order to confirm the diagnosis, then on the other side as well. The tendinous aponeurotic fibres on the anterior surface of the patella are then divided with a sharp

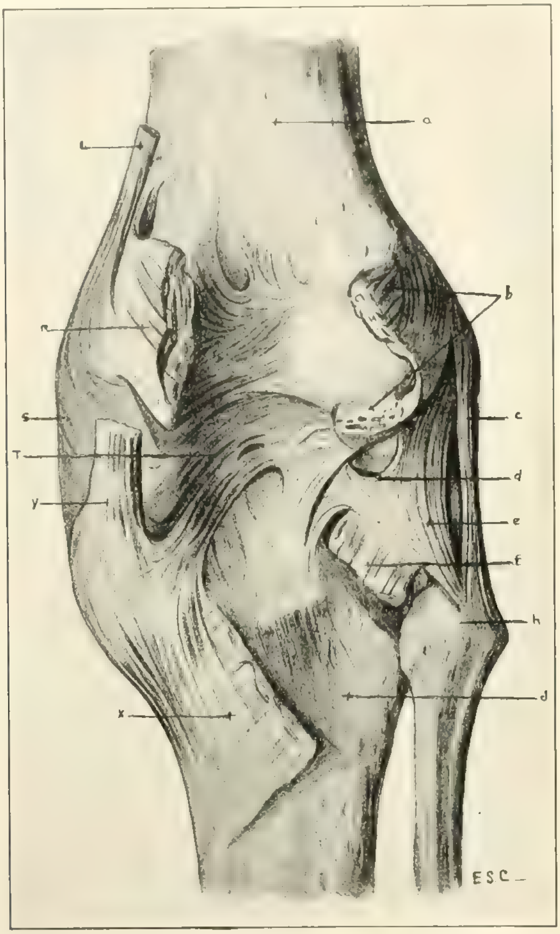


Fig. 240.—Right Knee Joint as Seen from Behind. (After Spalteholz.) *a*, Shaft of femur; *b*, plantaris muscle and outer head of gastrocnemius muscle cut through; *c*, external lateral ligament; *d*, ligamentum popliteum arcuatum; *c*, retinaculum ligamenti arcuati; *f*, popliteus muscle (cut through); *h*, head of fibula; *j*, tibia; *l*, tendon of adductor magnus muscle (cut through); *r*, inner head of gastrocnemius muscle (cut through); *t*, oblique popliteal ligament; *y*, tendon of semi-membranosus muscle (cut through); *z*, popliteus muscle (cut through).

knife, and the patella is sawed through transversely. The joint is now freely opened, and retraction of the patellar fragments upward and downward, together with acute flexion of the knee, will expose the joint to quite accurate inspection. Practically the same exposure of the joint may be obtained by a curved incision either above (*dd′*, Fig. 242) or below the patella. The lower incision begins likewise over one condyle, curves downward below the patella, and ascends to the opposite condyle. The capsule and ligamentum patellæ are divided along the same line, and this flap containing the patella is reflected upward. In the upward incision the convexity of the curve is upward. The deep incision divides the quadriceps just above the patella tendon, and the patella is reflected downward.

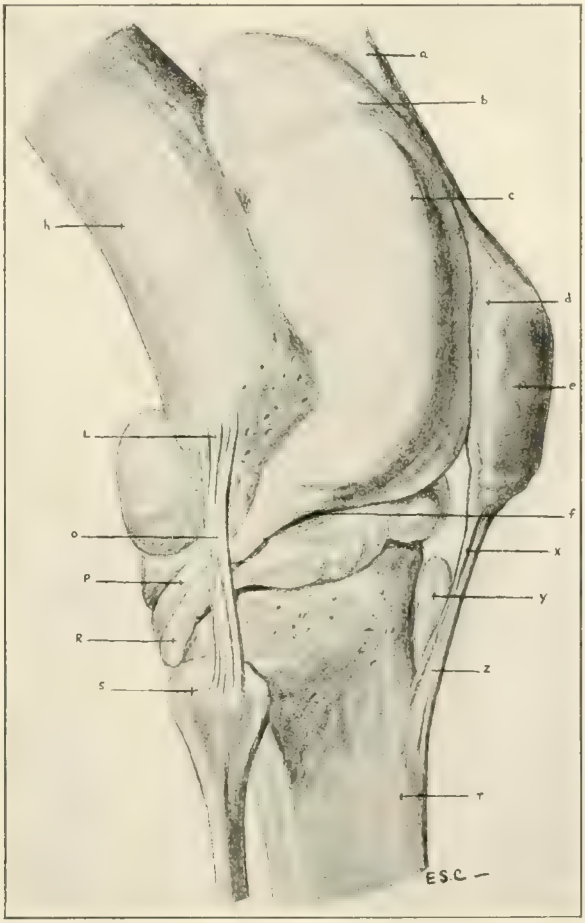


FIG. 241.—Knee Joint, Showing the Synovial Cavity and all Adjacent Bursæ Injected, then Dissected Out. (After Spalteholz.) *a*, Tendon of quadriceps femoris; *b*, suprapatellar bursa; *c*, cavity of joint; *d*, patella; *e*, subcutaneous prepatellar bursa; *f*, semilunar cartilage; *x*, patellar ligament; *y*, deep infrapatellar bursa; *z*, tuberosity of tibia; *t*, shaft of tibia; *s*, head of fibula; *r*, bursa of popliteus muscle; *o*, lateral fibular ligament; *l*, outer epicondyle; *h*, shaft of femur.

The crucial ligaments, if not already destroyed by disease, are now divided, and the incision is extended laterally in such a manner as to give easy protrusion of the bones from the wound. If the tissues are not diseased, a subperiosteal separation of the attachments of the lateral ligaments should be made. The posterior tissues are now retracted by a strip of gauze, and the femur is sawed across at right angles to the long axis of the bone. (Fig. 243.) The tibia is then pushed upward, and its articular surface is sawed off. (Fig. 244.) The exact position of this saw line in both bones will, in children, be governed chiefly by the location of the epiphyseal line, and in adults mainly by the extent of the disease. The primary excisions may prove to be insufficient to remove all disease, whereupon either a second slice is removed or the remain-

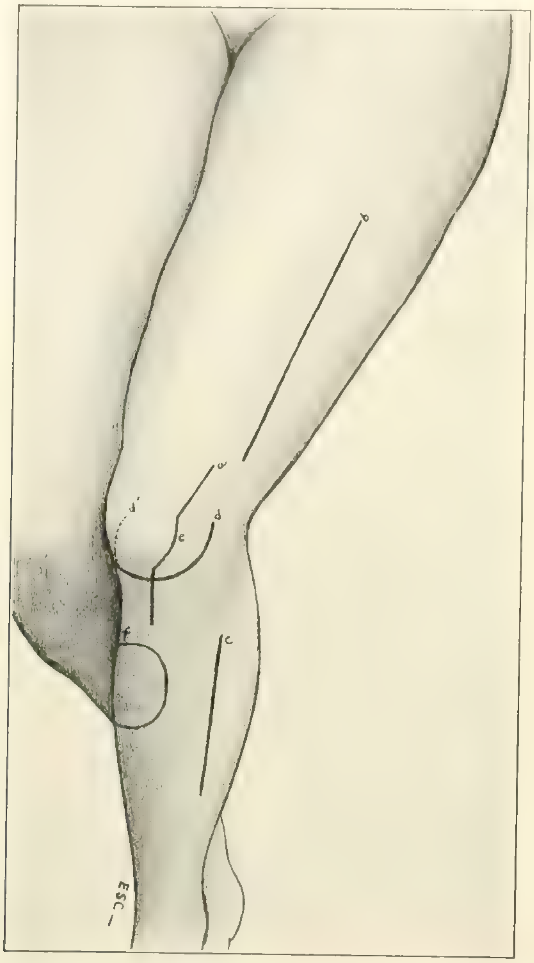


Fig. 242.—Incisions for Various Resections. *ae*, Ollier's incision for resection of the knee; *dd'*, lower curved incision for resection of knee; *b*, incision for resection of femur; *c*, incision for resection of fibula; *t*, flap of skin and periosteum flap for excision of limited area of necrosis in tibia. Flap is depressed and nailed into cavity after operation.

ing foci are to be excised. The presence of a focus of disease in one condyle is by no means an indication for higher division of bone. The von Mosetig-Moorhof method of plugging bone cavities with an iodoform mass (Vol. I., p. 724) has opened up a wide field for conservative atypical resections, and it is now possible in a great many cases to make the saw line in the position of choice, as regards function of the epiphyseal line, and to gouge or cut out any small focus that may be left. This excision of foci should be done, as far as possible, with a sharp heavy-bladed knife, and not with a curette. When the bone ends have been excised, a free field is presented for the removal of diseased soft tissues. In tuberculosis, this dissection should be done in a methodical manner with a very sharp knife. Any one starting-point may be chosen; then the entire synovial membrane should be removed in such a systematic manner that there will be no need of returning to any spot for the purpose of completing the dissection. During the removal, caution should be exercised so as not to infect the open ends of the exposed Haversian systems, and in some instances it will be wise to dissect away the disease as far as possible before sawing the bone. When an erosion of bone presents itself, a heavy knife should be used to shave off all suspicious bone tissue. All sinuses should likewise be excised. When the dissection has been completed, the field should be flushed with salt solution and wiped dry; and then, if the operation has been done for tuberculous disease, the entire joint should be thoroughly mopped with pure carbolic acid, which is left in contact with the tissues for about one minute. Alcohol is then used to neutralize the carbolic acid, and

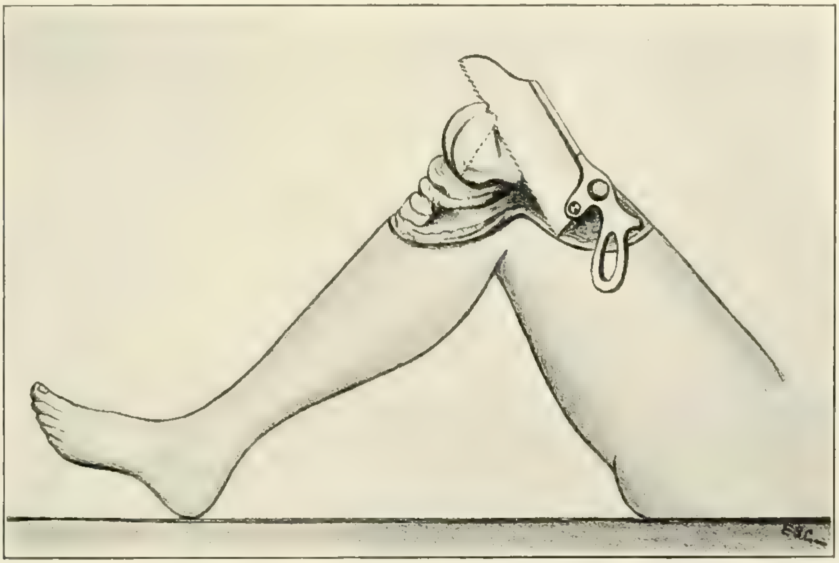


FIG. 243.—Resection of the Knee. (From Bryant's "Operative Surgery.") The joint cavity has been completely exposed by a horseshoe-shaped incision which curves downward below the patella.

the wound is ready for closure. The bones are fastened together by two or three heavy twenty-day chromicized catgut sutures which are passed through drill holes, abundant drainage is placed at each side, and the capsule of the joint is closed with No. 2 or No. 3 plain catgut sutures. The closure of the capsule is important and should be accurately done. In suturing the patella it is not necessary to drill the bone, since the firm tissues at either border and on the anterior surface furnish sufficient body for very firm and accurate suturing. The wound is now dressed and the joint is immobilized by a plaster-of-Paris splint applied in the manner shown in Fig. 245. The tourniquet is removed either before the wound is closed or after the dressings have been applied. The former method is safer unless surgical aid is at hand in case of hemorrhage. The construction of the splint (except as regards the two strips of hoop iron incorporated posteriorly) and the method of suspension are sufficiently explained by a reference to the illustration. The strips referred to are included in a five-inch strap of plaster, made by superimposing a sufficient number of layers of plaster-gauze bandage, and they give efficient reinforcement to the posterior support. These patients do not usually suffer great pain after operation when the leg is thus swung free from the bed and removed from possible injury. The dressings are usually not removed for five days, unless special indications arise, and the subsequent change of the dressings will depend largely upon the condition of the joint at the time of operation. If the joint has been free from pyogenic infection previous to operation, the drainage wounds will require very little or no further attention and will heal promptly; otherwise, there may be a continuation of the discharge for a considerable period.

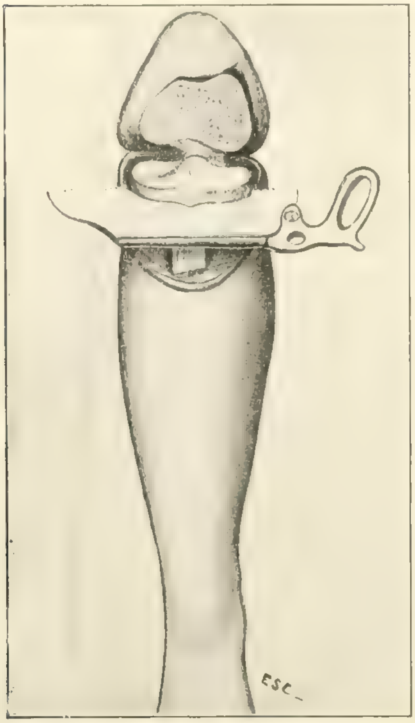


FIG. 244.—Resection of the Knee. (From Bryant's "Operative Surgery.") Saw in place for removal of the articular surface of the tibia.

After the lapse of from six to eight weeks bony union is usually secure and the patient may get about on crutches, but immobilization should be continued for a much longer time. Œdema and impaired muscular power will persist for quite a long period, yet the patient will return to a normal state in these respects quite as soon as it is wise for him to use the extremity for weight-bearing locomotion. Cases of excision for tuberculosis should be kept under very careful supervision for a considerable period, because of possible recurrence at some point of incomplete excision. A prompt secondary operation will, as a rule, save a joint that might otherwise go on to extensive reinfection and destruction and demand amputation.

Some surgeons have taken a rather indifferent attitude toward the fungous granulations found in a joint, stating that they will either undergo absorption or break down into caseous material and be discharged, or that they will be organized into useful fibrous tissue. From the standpoint both of pathological reasoning and of clinical experience, this advice would seem to the author dangerous. A conception of the disease which places it in the light of a process that manifests many characteristics of malignancy, and which bases the operation upon such conception of the disease, would seem very much more rational. The inveteracy of the disease should not be lost sight of for one moment during the entire course of the operation, and the dissection should be executed with the same care to effect a complete removal of all affected tissues that is employed in the removal of malignant tumors. A failure to apply such reasoning has undoubtedly contributed many bad results and has done much to bring the correctness of this operation into question.

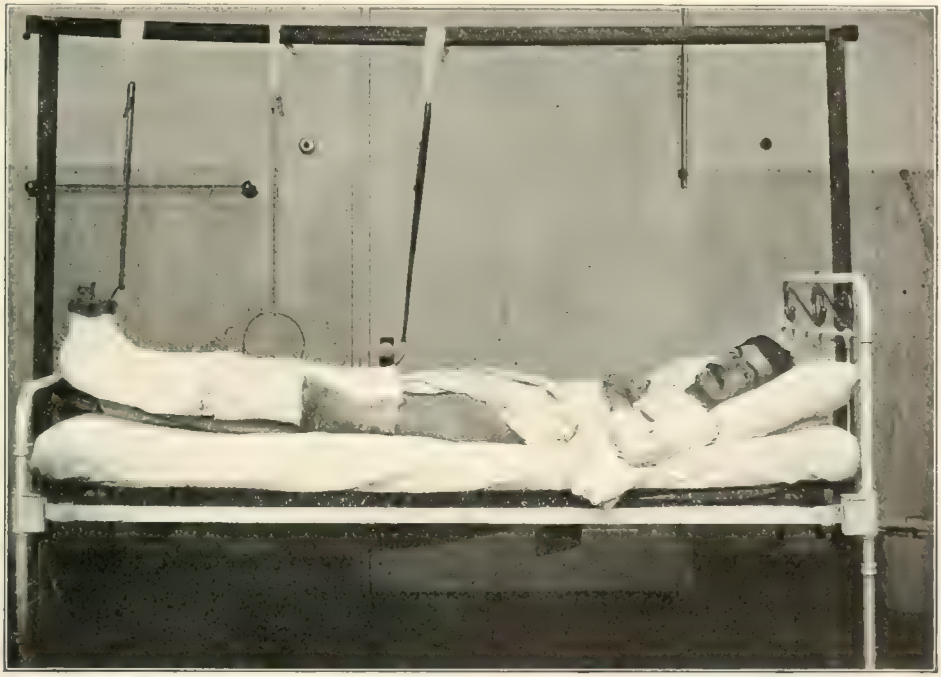


FIG. 245.—Suspension of Lower Extremity after Excision of the Knee. (Original.) The extremity is suspended by three heavy rubber tubes from a bar placed horizontally over the bed. The splint is interrupted at the knee.

Subperiosteal Excision of the Knee Joint.—Langenbeck describes an operation for excision which presents no advantage over that which has just been described, except, perhaps, that the anterior structures are not divided. It has the disadvantage of presenting much greater technical difficulties. The transverse incision gives such excellent exposure of the joint, and bony union of the patella is so entirely assured after resuturing the fragments, that there seems little reason for assuming the added technical difficulties of Langenbeck's method. The skin incision is shown in Fig. 242. The skin flap is reflected forward and the capsule divided in the line of articulation. The resection is completed subperiosteally. Small openings are made on either side posteriorly for tube drainage.

Ollier has likewise suggested an operation for subperiosteal excision. His incision (*ae*, Fig. 242) commences two inches above and to the outer side of the patella, descends to its upper outer angle, curves around the outer border to the apex, then descends vertically along the outer border of the ligamentum patellæ as far as its insertion. The operation is continued subperiosteally. Operation by an anterior vertical incision, which divides the quadriceps tendon, patella, and ligamentum patellæ longitudinally exactly in the middle line, has also been suggested. The lateral halves of the patella are retracted and the ends of both bones are satisfactorily exposed in a position of acute flexion. This incision is said to give an exposure of the joint which is equal to that given by the transverse incision, and it possesses the advantage of preserving unimpaired the anterior support of the knee.

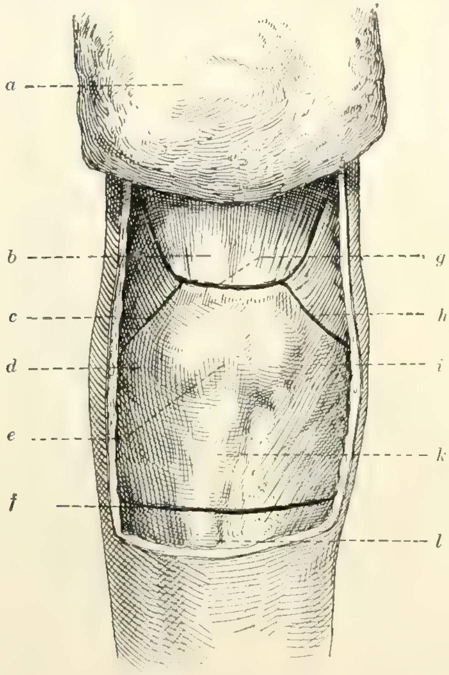


FIG. 246.—Excision of the Knee without Opening the Joint. U-shaped incision in quadriceps extensor; internal and external lateral incisions in fascial expansions of quadriceps; transverse incision over head of tibia. (Flint, in *Annals of Surgery*, March, 1906.) *a*, Skin flap turned up; *b*, quadriceps extensor tendon; *c*, external lateral incision; *d*, joint; *e*, patella; *f*, transverse incision; *g*, U-shaped incision in muscle; *h*, internal lateral incision; *i*, joint; *k*, tendon of patella; *l*, tubercle of tibia.

Excision of the Knee without Opening the Joint.—Carleton P. Flint (*Annals of Surgery*, March, 1906) describes an operation for the excision of tuberculous joints which avoids all dangers of smearing tuberculous or pyogenic material over normal tissues, avoids hemorrhage, and is said to save much time. This operation was first described by Nicholas Walkowitch, Kiew, Russia, in the journal *Wratch* (1896, No. 31), and subsequently, by the same author, in the *Deutsche Zeitschrift für Chirurgie* (Bd. 74, 1904). The operation may be described—partly in the author's words and partly in our own—as follows:

A rectangular flap of skin and subcutaneous tissue is first dissected upward, as indicated in Fig. 246. The next incision is made in the deeper tissues and with the concavity upward. It starts in the vastus internus, a little above the upper limit of the subcrural bursa, and is carried downward and outward in the direction of the muscle fibres of the tendon of the quadriceps extensor, one-half inch above the patella, and from here upward and outward in the direction of the fibres of the vastus externus to a point corresponding to the beginning on the inner side (*g*, Fig. 246). The muscle with the tendon is completely divided and turned upward, thus exposing to view the subcrural bursa (*f*, Fig. 247). Two small incisions are next made, one on either side of the femur; they start on each side of the patella, in the incision just described, and are carried downward and backward to the joint line (*h*, *e*, Fig. 246). The one on the inner side divides the tendinous expansion of the quadriceps, while that on the outer side divides the tendinous expansion and part of the ilio-tibial band. After these incisions have been completed, the subcrural bursa is separated from the femur with the knife and turned down, the patella being tilted when it is not adherent. The last incision in front is carried transversely across the front of the tibia down to the bone, just below the joint line (*f*, Fig. 246). On the inner side the sartorius and the gracilis are pushed back; on the outer side, the biceps and peroneal nerve.

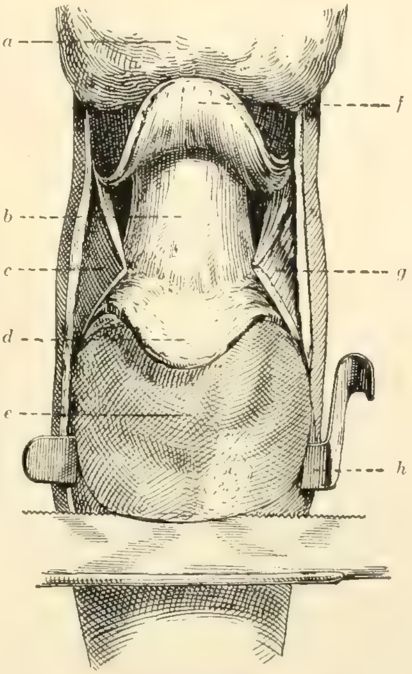


FIG. 247.—Excision of Knee without Opening the Joint. Muscle incisions; bursa turned down; retractor in place; saw cutting tibia. (Flint, in *Annals of Surgery*, March, 1906.) *a*, Retracted skin flap; *b*, femur; *c*, vastus externus; *d*, subcrural bursa; *e*, patella; *f*, quadriceps extensor turned up; *g*, vastus internus; *h*, retractor behind tibia.

A flat retractor about one inch wide is now introduced on the inner side behind the head of the tibia, close to the joint line (*h*, Fig. 247). It is first introduced vertically between the gracilis and the sartorius on one side and the tibia on the other. These muscles are pried off and the retractor is brought to a horizontal plane, the apex passing behind the tibia. This retractor is now pushed outward, always close to the bone, until it emerges at the outer side. All soft parts are thus held back.

The next step is to saw through the tibia as close to the joint as circumstances seem to warrant, the leg being still flat on the table and the soft parts being protected by the retractor, which is still retained in place. (Fig. 247.)

The saw-cut through the head of the tibia is used as a joint. The femur is flexed on the body, and the leg on the femur (Fig. 248), and with a large knife the soft parts are quickly separated from the posterior structures of the joint. By a little downward traction on the leg, combined with the pull of its own weight, injury to the vessels is easily avoided. This seems to be much more readily accomplished in this manner than by the operation which attacks the posterior structures of the joint from the anterior aspect. One has at least a better sense of security because one is perfectly sure of the relation of the vessels to the knife.

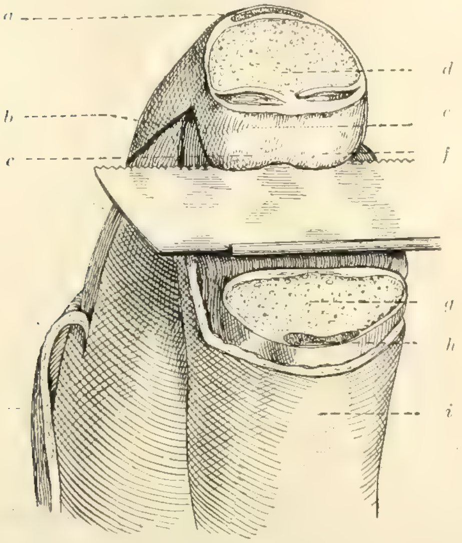


Fig. 248.—Leg Flexed on Thigh; Condyles Exposed; Saw in Place for Section of Femur. (Flint, in *Annals of Surgery*, March, 1906.) *a*, Tendon of patella; *b*, lateral cut in vastus; *c*, condyle of femur; *d*, upper section of tibia; *e*, line of joint; *f*, condyle of femur; *g*, tibia; *h*, tendon of patella; *i*, tuberosity of tibia; *k*, skin flap turned back.

As soon as the posterior region of the condyles is exposed, the femur is sawed through from behind forward and slightly downward at a level which will permit the saw to clear the cartilage behind. (Fig. 248). This saw-cut is carried forward until it reaches the margin of the cartilage on the anterior surface of the femur, and the saw is then withdrawn. The direction of this cut should be downward and forward so as to effect as small a loss as possible of the femur and also to obtain the desired slightly flexed position of the bones subsequently. It is easy to be deceived as to the exact position of the cartilage behind. The operator should examine the relations of the parts with particular care at this stage of the operation, as otherwise the saw-cut in the femur may be made too high up.

After the saw has been withdrawn from the femur, the leg should once more be placed in the horizontal position. The saw is introduced behind the subcrural bursa at the upper margin of the articular cartilage on the front of the femur, and a cut is made which will meet the anterior limit of the horizontal saw-cut that was made from behind. (Fig. 249.) This last cut is almost vertical, in the coronal plane, and allows the articular portion of the femur, which extends upward in front, to be removed with the joint.

This is the last step of the incision proper, for it is now possible to lift out *en masse* all the structures which immediately compose the joint (the patella, the subcrural bursa, and the articular surfaces of the femur and tibia) without having opened the articular cavity. Up to this point a tourniquet is used, but now it is removed and the bleeding points are quickly clamped and tied, thereby reducing the hemorrhage to a minimum. Inasmuch as this part of the operation takes but little time—in fact only about ten minutes, or even only six minutes in easy cases—we do not see why the tourniquet might not be left on for a still longer time and thus insure complete hæmostasis.

Without stopping to describe the intermediate steps, which present no points of special interest, we may pass on at once to the final ones of the operation. Dr. Flint unites the bones with No. 4 chromicized catgut, six stitches being passed directly through the bone with a Hagedorn needle of large curve. (Fig .250.) It is usually unnecessary to bore holes, the cortical portion of the lower part of the femur and upper region of the tibia being so thin that it can be readily penetrated by a needle. The needle goes slowly at first and should be held in the holder about one inch from the point, so as to prevent it from breaking.

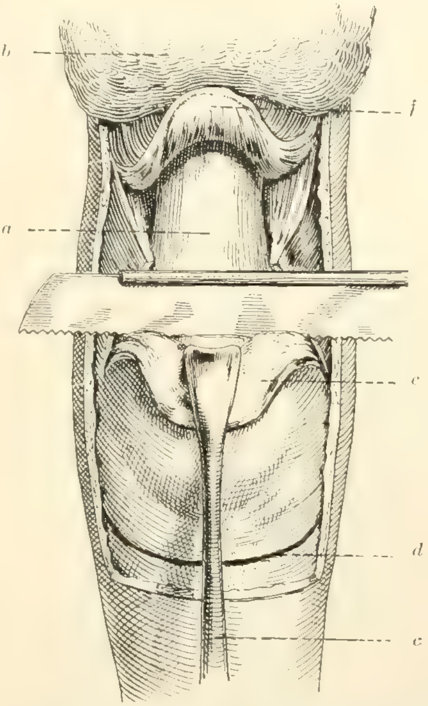


FIG. 249.—Excision of the Knee without Opening the Joint. Leg horizontal; bursa pulled down; saw in place to remove trochlear surface of femur. (Flint, in *Annals of Surgery*, March, 1906.) *a*, Femur; *b*, skin flap turned up; *c*, retractor; *d*, saw-cut in head of tibia; *e*, bursa turned down; *f*, quadriceps extensor.

When examination of the cut ends of the bones reveals such an amount of disease left behind as to render curetting inadequate and demand removal of another piece of bone, then we are liable to get into the region where the cortex is so thick as to make this method of suturing impracticable. In such a case we are obliged to resort to the use of a drill.

After the bone has been sutured, the muscle and skin flaps are turned down and sutured in place. As a rule, the amount of retraction in the rectangular skin flap about compensates for the shortening due to resection, and consequently secondary trimming of the skin is not necessary.

There are, of course, extreme cases—*i.e.*, cases with either very little tuberculous disease or with very extensive involvement—in which the operation just described would not be feasible.

The advantages of the operation may be summed up as follows:

1. It requires very little time.
2. There is very little danger of contamination of the wound by tuberculous or other infection from the joint.
3. Hemorrhage can be reduced to a minimum.
4. The operation is thorough, there being but slight chance of leaving diseased tissue behind, and the probability of recurrence being thereby diminished.

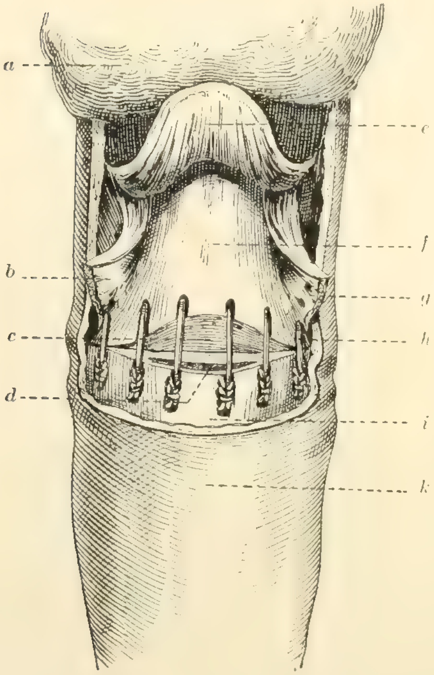


Fig. 250.—Excision of the Knee without Opening the Joint. Femur and tibia approximated; sutures in place. (Flint, in *Annals of Surgery*, March, 1906.) *a*, Skin flap turned up; *b*, tendinous expansion of vastus externus; *c*, vertical cut in femur; *d*, tendon of patella; *e*, muscle flap turned up; *f*, femur; *g*, tendinous expansion of vastus internus; *h*, chromicized-gut sutures; *i*, tibia; *k*, tubercle of tibia.

General Remarks upon Excision of the Knee Joint.—When a limb is ankylosed in a flexed position, an effort should be made to straighten it by means of extension before operation. Resection in a flexed position requires the removal of a large amount of bone to straighten the limb, and, unless a requisite amount be removed, always subjects the posterior soft tissues to the danger of undue pressure or tension on straightening the limb. Whitman has advocated, for overcoming flexion deformity, a method of procedure which promises to be of service. The patient is anæsthetized and placed face downward upon a table with pillows so arranged beneath the abdomen that the anterior surface of the tibia will rest evenly upon the table. The operator then holds the head of the tibia firmly against the table with one hand and, with the ulnar border of the other, begins forcible massage upon the contracted hamstrings. This massage is begun half way up the thigh, and, as the resistance lessens, the body is gradually lowered. In contractures of long standing, with subluxation, it will not be possible to complete the correction at the first operation. In forced extension of the leg under these circumstances, care should be taken not to overstretch the tissues of the popliteal space, especially the nerves and vessels. Great pain attends the former and rupture the latter stretching.

Reference has already been made to the conservative treatment of disease foci which extend in an isolated manner into the sawed extremity of the femur or tibia. It should be further stated that deeply congested cancellous bone tissue may also be preserved, especially when its removal will endanger the epiphyseal line.

Various methods have been suggested for holding the bones together. Metallic sutures, bone pegs, and nails, driven from without through the integument and bone, are efficient in many cases in holding the sawed surfaces firmly together and may be used. While it is a matter of the greatest importance to retain the bone surfaces in accurate apposition and to prevent the interposition of soft tissues, particularly in the posterior portion, it should be remembered that the use of all such devices is open to the objection that they may cause irritation and require subsequent removal. If the position can be maintained by the use of absorbable sutures or by apparatus alone, this course is much to be preferred. The author uses No. 3 or No. 4 chromicized-catgut sutures for holding the bones in accurate position, yet his chief reliance is placed upon an accurately fitting splint. The support afforded by a splint should be maintained in these cases for a much longer time than that usually needed in the treatment of fractures, since firm organization of the callus is often much delayed by low nutritional conditions in the bone ends. Great care should be exercised in sawing the bone surfaces correspondingly, otherwise a crooked limb will be the outcome of bony apposition. A straight limb should be the aim.

The causes of failure after excision are: (1) Failure in removing all tuberculous tissue. (2) Unhealthy condition of the bone ends, with persistent osteomyelitis. (3) Imperfect immobilization. (4) State of low general nutrition which makes it impossible for the wound to heal. (5) Tuberculous infection developing in other parts of the body. (6) Infection by pyogenic germs.

Erasion of the Knee Joint.—Erasion of the knee joint is an operation which has a definite field of application in the treatment of tuberculous joints. By erasion is meant a systematic removal of the diseased synovial membrane, diseased ligaments, and superficial disease of the bones and cartilages of a joint. It is used as a substitute for excision when the disease is limited to these structures, and it possesses the following advantages: (1) No bone slices having been removed, there is no loss in the length of the limb. The saving of normal bone ends is justified by clinical experience, which shows that the weight-bearing function of a joint treated in this way is equal to that of an excised joint. (2) There is no possible danger of destroying the epiphyses. This makes of it the operation of choice in children. (3) Motion in the joint has been looked upon as an object to be attained by this method. This is probably a mistake, and many of the unsatisfactory results which have been reported as following this treatment, such as flexion deformity, are doubtless due to an effort to obtain motion. A fixed ankylosis in a straight position should be sought. (4) The ligaments of the joint are preserved, as a rule, an almost normal stability follows, and a speedy and firm union is obtained. (5) If the operation is performed early, the patient is saved both destruction of tissue and loss of time. In the case of children, the saving of bone means a great deal.

When the operation was proposed by Wright, in 1881, hopes were entertained that relief from all disease, followed by motion in the joint, might be accomplished in a fair number of cases. As has already been stated, however, this effort to secure motion defeated the proposition. Efforts to secure motion resulted in the formation of a fibrous or cartilaginous synostosis, usually with slight flexion, and this flexure was progressively increased by the weight of the body. The very frequent occurrence of such unfavorable results led to the abandonment of the operation in very large measure. This objection is now removed by the demonstration that erasion, with subsequent immobilization, will give an excellent weight-bearing limb, one that has little tendency to flexion deformity. The author has operated by this method upon six cases of synovial tuberculosis in adults. Five of these cases have not developed a flexion deformity; all have recovered from the tuberculous disease; and all possess good weight-bearing limbs. One of these cases required a secondary operation for the removal of a small remaining focus. The sixth case was operated upon in the usual way; and, after the lapse of an entirely inadequate period of time, the physician who had originally sent in the case for operation decided that the sinuses would not heal, and, possibly unwisely, he amputated at the middle of the thigh. The author is of the opinion that a secondary operation or an excision, if done at the proper time, might have saved this extremity.

Synovial tuberculosis is, in the author's experience, much more frequent than has been recorded by other observers, and it has not seemed to him wise to remove good bone ends in these cases. The correctness of the judgment has certainly been borne out by the excellent results that have thus far been obtained.

The technique of the operation differs in no way from that already described in the section relating to excision, except that the bone ends are not removed. The same scrupulous care in dissecting away diseased tissue should be observed.

Should erasion fail to cure the disease, the joint is undoubtedly left in a less satisfactory condition, anatomically, for excision than if the parts had not been previously operated upon; yet this is true of any secondary operation. Erasion will fail because of incomplete removal of tuberculous material, of imperfect asepsis, or of such a lowered condition of the patient's vitality that the wound cannot heal.

I will close by adding that the original distinction between excision and erasion has in a very large measure disappeared. The modern atypical operation for tuberculous joint disease often, if not usually, partakes of the characters of both. There are many cases in which there is a well-defined reason for adhering strictly to one method or the other; yet, as a matter of fact, the two differ only in the circumstance that the bone ends are sawed off in an established way in the one operation, and are merely pared, when diseased, in the other operation. The objects to be attained are the same in both operations, namely, a complete removal of diseased tissue and a stable stiff knee.

Excisions of the Tibia.—Partial or total resection of the tibia may become necessary for necrosis, for an injury, or for the removal of a tumor.

Acute osteomyelitis attacks the tibia with great frequency and often results in the destruction of small or large segments of the entire diameter of the diaphysis. One-third, one-half, or even the entire shaft of the bone may become necrotic. The indications for the removal of dead bone are perfectly clear, for recovery cannot otherwise occur; yet a serious difficulty arises in the treatment from the fact that the operation of resection removes the weight-supporting shaft of the leg. The chief difficulties in the operation will therefore relate to this one point. Many methods have been suggested for the filling of the defects left by the removal of dead bone. Bone chips have been used as a basis for regeneration, and the bones of animals have been transplanted, yet neither of these methods has proven uniformly successful. Amputation should certainly never be considered until it has been clearly demonstrated that subperiosteal resection or fibular transplantation is impracticable.

Much may be done, in the treatment of acute osteomyelitis, to prevent the extensive destruction of bone that will demand resection. Prompt drainage, by operation, of both the soft tissues and the medullary cavity, will usually result in a strict limitation of the destruction to the immediate area of primary infection. This first operation is never extensive. After the disease has been arrested in this manner, the regenerative powers will promptly assert themselves, both in the periosteum and in the endosteum, and at the end of about two months "the periosteal proliferation and ossification will have advanced to a stage that will make certain the bone-forming ability of the membrane, and will make it sufficiently rigid to allow of accurate manipulation, without, however, the ossification being so advanced as to produce a rigid non-plastic bony tube." (Nichols.) The time at which this stage is completed will vary somewhat from the average time stated above, and can be roughly estimated by thrusting a needle through the periosteum at the side of the sinus. When the needle passes first through soft tissue, then through a thin crackling layer of bone, and finally encounters the hard necrotic shaft, the desired stage of regeneration has been reached, and the patient is ready for the removal of necrotic bone. Nichols has fully demonstrated the capacity of this hypertrophied periosteum to regenerate new bone, even an entire diaphysis.

The Operation.—An incision is made in the long axis of the bone and at a point where the bone lies near to the surface. This incision is carried down to the bone through the periosteum, and this membrane is separated, with the very greatest care, from both sides of the necrotic shaft. In some cases numerous adhesions will be encountered, while in others the membrane is found to be so loosely attached to the bone that separation may be accomplished with great ease until the posterior border is reached. If one end of the shaft is movable, it should be seized and lifted with lion-jaw forceps, thus facilitating the posterior dissection: or, if neither end is detached, the bone should be divided at the most practicable point, the ends lifted up, and the dissection then completed. When the entire shaft is not involved, the line of demarcation will be indicated by the condition of the periosteum, by the amount of granulation tissue and pus located between the periosteum and the shaft, and by the condition of the marrow. The shaft should be removed until a point is reached where the periosteum is not separated from the bone, and where the marrow is vascular and non-infected. Fortunately, as a rule, the epiphyseal lines are not invaded, and the preservation of even a disc of bone beyond this line will insure the patient against future shortening from arrested development.

After the bone has been removed, there will be left a periosteal tube which is pinkish white in color, plastic, and crackling in consistency. The surface should be wiped dry, then sterilized with pure carbolic acid, and afterward neutralized with alcohol. The periosteum should next be folded together in such a way as to make a flattened ribbon, and should be held in this position by chromicized-catgut sutures. The wound should then be closed, with provision for drainage, and the leg carefully immobilized. In about three weeks a marked induration will be felt along the line of the bone, and in from five to eight months the bone will have regained its normal size and can be used freely. Minor secondary operations for persistent sinuses may be necessary in some cases. The after-treatment includes: (1) Most careful immobilization; (2) the application of aseptic dressings at frequent intervals; (3) the careful shaping of the parts with bandages and adhesive plaster as the bone develops; (4) abstinence from use of the limb until the bone is sufficiently strong; and (5) careful attention to the general health.

Excision of the Tibia for Giant-celled Sarcoma.—From recent facts brought forward by Bloodgood, Kramer, and Jenckel, it would seem that, in giant-celled sarcoma of the tibia, excision of the tumor-bearing segment of the bone, or a partial operation which does not destroy its continuity, should be substituted for amputation. This advice applies only to giant-celled sarcoma and to those cases in which the new growth has not infiltrated the soft tissues. Several cases are now on record in which this conservative operation has been done successfully; the patients being alive and well several years after the operation.

OSTEOPLASTIC OPERATIONS ON THE TIBIA.—Compound fractures, gunshot wounds, and resection for tumors will sometimes result in the total loss of all bony and periosteal tissue throughout a length of several inches. Under these conditions amputation may be avoided by grafting the fibula into the gap. The fibula will undergo a compensatory hypertrophy, and an efficient weight-bearing leg will be secured.

Excision of the Fibula.—The fibula is subject to the same lesions that have been described for the tibia, and precisely the same measures are to be applied for their relief.

Excision of the Ankle Joint.—A considerable difference of opinion prevails as to the value of excision of the ankle joint; the preponderance of opinion being against its utility. This latter opinion, however, applies mainly to the use of this operation in the treatment of tuberculous disease, and is based upon the following facts: (1) That results have not been good because of frequent associated disease in the tarsus; (2) that the final usefulness of the ankle is not good; and (3) that modern prosthetic apparatus, for use after ankle and leg amputations, make very useful limbs. It must be granted, however, that those operators who use the anterior transverse incision, in select cases, and who execute a careful dissection of all diseased tissue under these very favorable conditions of exposure, are less inclined to dispute the value of excision of the ankle for tuberculosis. All operators agree that the operation offers a more promising outlook in conditions other than tuberculous disease.

The indications for the operation are: (1) Compound fractures; (2) dislocations followed by suppuration; (3) suppurative arthritis which has not yielded to free drainage; (4) advanced cases of infantile paralysis; (5) tuberculous disease occurring in young patients and limited to the ankle joint; (6) bad fracture of the astragalus, with posterior displacement.

ANATOMICAL CONSIDERATIONS.—The complicated structure of the ankle joint calls for a close study of the position, relationship, and function of each anatomical element in its neighborhood. The location of the main vessels and nerves behind the inner malleolus will determine the location of the main incisions on the outside of the joint. The location of the epiphysis, the position of tendons, and the expansion of the synovial membrane are important elements to consider in planning incisions and in carrying out a dissection for disease.

THE OPERATION.—When the operation is done for conditions other than tuberculosis, two lateral incisions are used; when it is done for tuberculosis, a transverse incision is made from one malleolus to the other across the front of the joint.

Excision by Two Lateral Incisions.—The extremity is elevated to drain out venous blood, a tourniquet is applied, and the foot is laid on its inner side, firmly supported by a sand bag. An incision is carried downward along the lower two and one-half inches of the posterior border of the fibula, and, at the tip of the malleolus, it is inclined forward at an angle and terminates within an inch of the base of the fifth metatarsal bone (*a*, Fig. 251). The skin flap thus formed is dissected forward to expose the fibula and the peronei. These muscles are pulled to one side, the fibula is exposed and divided with a saw two inches above the tip of the malleolus, and the fragment is removed after the external lateral ligament has been divided. This wound is now protected and a similar incision is made on the inner side. The inner incision is made along the lower two inches of the inner border of the tibia, and then carried downward and forward to the projection of the internal cuneiform bone (*b*, Fig. 252). This flap is likewise dissected forward in such a manner as to expose the tibialis anticus, the tibialis posticus, the flexor longus digitorum, and the flexor longus pollicis. These muscles are carefully isolated, the knife being kept very close to the bone in order to avoid injury to the posterior tibial vessels. The internal lateral ligament is now divided, and the articular surfaces of the tibia and astragalus are made to present themselves in the wound by displacing the foot outward. A metacarpal saw is next passed through the joint from the inner side, and a slice of bone is removed—a slice just thick enough to include the cartilage or the eroded bone. A similar slice is then removed from the upper surface of the astragalus with a saw, and all remaining articular cartilage is dissected away with a knife. In some cases—as, for example, those of necrosis of the astragalus, or cases of bad fracture of the astragalus—this bone is entirely removed. All bleeding points are secured, the wounds are drained and dressed without suture; and the foot is put up at right angles to the leg in a position midway between abduction and adduction, and securely immobilized. Maintenance of this accurate position is quite essential to a good functional result. Chromicized-catgut sutures, carefully placed in the soft tissues, will aid greatly in maintaining the position of the bones until the splint is applied.

A very satisfactory immobilization can be maintained by a plaster-of-Paris splint made as follows: An ordinary plaster-of-Paris bandage, four inches wide, is rolled out on a table in superimposed layers, to make a strip that will extend from the middle of the thigh, along the posterior surface of the leg, over the heel, and at least one inch beyond the toes. The strength of this strip will depend upon the number of layers that have been superimposed, and it may be reinforced by a piece of hoop iron, three-fourths of an inch wide. A similar strip, three inches wide, is placed upon the anterior surface of the extremity, and the two are held in accurate position and moulded to the limb. A splint of this variety has two advantages—(1) it is readily available, and

(2) both wounds can be dressed from the sides without disturbing in the least the immobilization of the parts. It will be of advantage in dressing the wounds to narrow these plaster strips at the ankle by cutting out scallops on each side. Particular care should be taken, at the time of the primary dressing, to apply the gauze pads to the wound in such way that they can be removed without disturbing the splint or altering the position of the bones. Continued immobilization is, in reality, the most important factor in the after-treatment. It

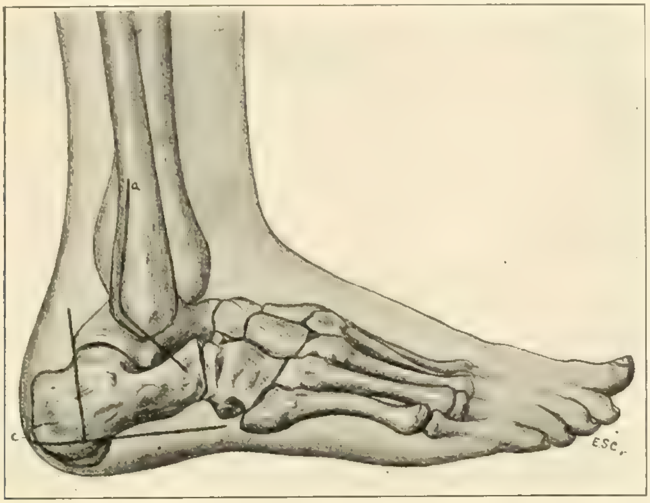


Fig. 251.—Excision of the Ankle Joint and the Os Calcis. *a*, Outer incision in resection of the ankle by two lateral incisions; *c*, excision of os calcis.

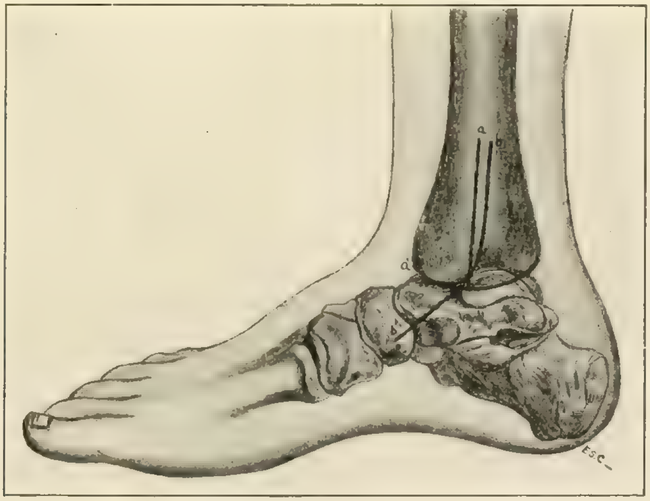


Fig. 252.—Excision of the Ankle Joint. *ad*, Langenbeck's inner incision; *b*, inner incision in the operation of excision by two lateral incisions.

will often add greatly to the comfort of the patient to swing the extremity from above, as in knee resections. (See Fig. 245.)

The period of drainage in such a wound will vary from forty-eight hours to one week, according to the conditions for which the operation was performed.

Immobilization should be continued for six weeks. During this period the patient may be allowed to go about on crutches; and, after two or three weeks, the foot should be frequently removed from the splint, soaked for a period of two hours in hot salt solution, and then replaced in the original splint. A firm nearthrosis, with very slight motion, gives the most desirable result; yet a firm ankylosis is almost as useful, since the tarsal articulations acquire an increased range of mobility, which aids materially in the gait. It is, therefore, unwise to make special efforts to obtain motion. The necessary solidity is usually attained when the operation is done subperiosteally. In resecting the bone ends a broad flat chisel or an osteotome is often, if not usually, preferable to the saw.

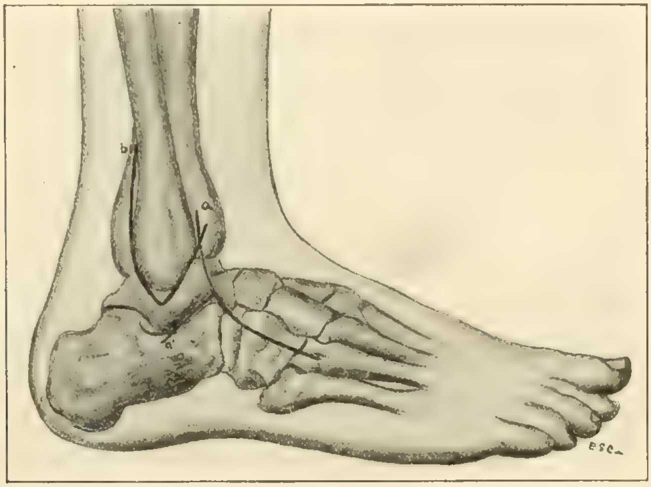


Fig. 253.—Resection of the Ankle Joint. *b*, Langenbeck's outer incision; *aa'*, Vogt's incision for excision of the astragalus.

The operation just described is a modification of Langenbeck's method. The incisions used by this authority are shown in Figs. 252 and 253. In suppuration of the ankle joint, a partial excision may become necessary in order to secure good drainage. A part of the malleoli may be removed subperiosteally through posterior incisions, as has been suggested by Ollier; or the astragalus, or a part of the same, may be removed, instead of the malleoli. As has already been stated, the modern surgery of joints tends strongly to the conservative atypical excision; and in the ankle, as elsewhere, the surgeon more frequently adapts the operation to the case in hand than the case to a typical excision.

Excision by Anterior Transverse Incision.—For tuberculosis of the ankle joint, excision by a transverse incision is very much to be preferred, since other methods do not expose the remote recesses of the joint as fully as is essential to a careful and complete dissection. This fact will doubtless explain in a measure the ill-favor which attaches to the operation of excision for tuberculosis. The operation was devised by Heyfelder and Sédillot, and revived by Hueter, and is now practised by many.

The Operation.—The incision is made directly across the anterior surface of the ankle from one malleolus to the other, and should divide the skin, superficial fascia, and the tendon sheaths along its entire course. (Fig. 254.) Externally, the peroneal arteries and the tendons of the peroneal muscles should be drawn to one side. Internally, the posterior tibial artery and nerve should be protected. Each remaining tendon on the dorsum is then lifted up in turn, fine sutures are passed through them at two points, about one inch apart, and each suture is left long and clamped. The tendons are now divided between these sutures, and each suture serves as a guide to accurate resuturing. The joint is opened by completing the transverse incision, and the foot is forced backward until the sole rests upon the calf of the leg. The joint is now as freely open as are the pages of a book, and a systematic dissection of all tuberculous tissue may be accurately executed. This sharp-knife dissection is, in reality, the secret of success in the operation; and every operator should adopt a sort of system in covering the synovial membrane, and should dissect carefully as he goes, in order that no diseased tissue shall be left. An attempt to curette the disease here and there, until it has all been removed, usually results in leaving some diseased tissue. When the joint has been freely opened, the decision can be promptly made as to whether an excision or an erasion should be done. If the bones are diseased, they should be sawed off in the usual manner. If the articular surfaces of the tibia and fibula are uninvolved, they should be left, since lateral support of the malleoli adds greatly to the stability of the limb.

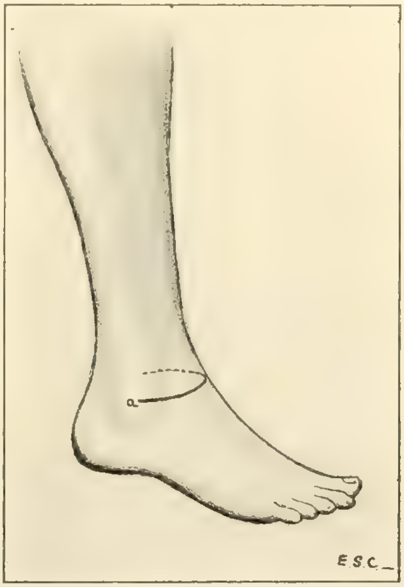


Fig. 254.—Excision or Erasion of the Ankle Joint by a Transverse Anterior Incision.

The inferior tibio-fibular joint is of particular importance in tuberculosis, and a proper separation of these bones should be secured, in order to make certain that no diseased synovial membrane is left. The astragalus is frequently involved, and the calcaneo-astragaloid joint is often the seat of infection. In not a few cases it becomes necessary to excise the astragalus; and if there should be any question as to the condition of this bone, it should be either excised, or tuberculous material should be cut out by sharp dissection, and the cavity filled with von Mosetig-Moorhof's iodoform plugging material. When the dissection has been completed, the joint should be thoroughly mopped with pure carbolic acid, which is to be left in contact for about one minute; then alcohol should be applied freely. The tourniquet is now removed, all bleeding points are secured, and the joint is closed, with proper provision for drainage. The capsule is accurately sutured with chromicized catgut, each tendon in turn is sutured, and the tendon sheaths are closed with very fine, plain catgut sutures. The superficial fascia and skin are then sutured, the latter with silkworm gut; the foot is carefully dressed; and an efficient plaster-of-Paris splint is applied.

This operation will save many patients from the necessity of an amputation; and the results are most satisfactory, both as regards function and as regards a cure of the tuberculous trouble. The free exposure of the joint insures complete removal of all tuberculous trouble. The ankylosis which follows is compensated for by the tarso-metatarsal joint; and the anterior tendons which have been divided return to their normal function.

It is not always possible to determine, before operation, the full extent of a tuberculous lesion in the ankle, and, as has already been stated, an involvement of many tarsal bones may make resection quite undesirable. Amputation at the junction of the middle and lower thirds of the leg then becomes necessary. The transverse incision possesses the great advantage that it gives information, at the very outset of the operation, as to tarsal involvement, and consequently very little time is lost in applying the alternative operation.

Many other operations have been devised which are applicable in tuberculous disease of the ankle.

Kocher operates through an outer curved incision, made along the posterior border of the lower four or five inches of the fibula and carried forward under the malleolus, at the level of the calcaneo-astragaloid joint, to the point of insertion of the peroneus tertius. The sheaths of the peronei are exposed and opened lengthwise. The external malleolus is exposed by subperiosteal dissection, and the joint is opened in front. The outer surface of the astragalus is exposed; the periosteum and capsule are separated from the tibia in front and behind, and the articular surfaces are turned out and chiselled away.

Ollier's incision for resection is shown at *a*, in Fig. 255.

Vogt uses a long anterior and a transverse lateral incision similar to that of Ollier, and recommends removal of the astragalus in all cases.

RESULTS.—In the non-tuberculous cases, and particularly after subperiosteal resection, repair is usually rapid, and early usefulness of the foot is the rule. The malleoli will be reproduced. The shortening will depend upon the amount of bone removed and can be readily overcome by wearing a thick sole on the shoe. As stated above, a firm nearthrosis with some motion furnishes the most satisfactory result; yet firm ankylosis is almost equally satisfactory, since a compensatory increase in the range of motion in the tarsus usually gives an easy gait.

In tuberculous disease the results are especially good, both as to cure and as to function, when the operation is performed early in children and in young persons. In adults the results should be equally good if the cases are properly selected and if the dissection is carefully made.

Osteoplastic Resection of the Tarsus by the Wladimiroff-Mikulicz Method.—This operation is of value in extensive gunshot wounds of the heel; in paralytic talipes, where it is desirable to fix the ankle and lengthen the leg; and in all cases of tuberculous disease of the ankle and tarsus associated with extensive ulceration of the heel. A transverse plantar incision is made from the inner side, in front of the tuberosity of the scaphoid, to a corresponding point on the outer side of the foot, just behind the base of the fifth metatarsal. (Figs. 256 and 257.) This incision is carried down to the bone. A second transverse incision divides the tendo Achillis at a point slightly above the ankle joint. The ends of these two incisions are now connected on either side of the foot by incisions carried down to the bone. The foot is next flexed sharply, the ankle joint is opened from behind, the lateral ligaments are divided, and the os calcis and the astragalus are removed, together with the soft parts of the heel. A layer of bone is now sawed from the exposed extremity of the tibia and fibula (including the malleoli) and also from the exposed surface of the cuboid and scaphoid. The posterior tibial and external and internal plan-

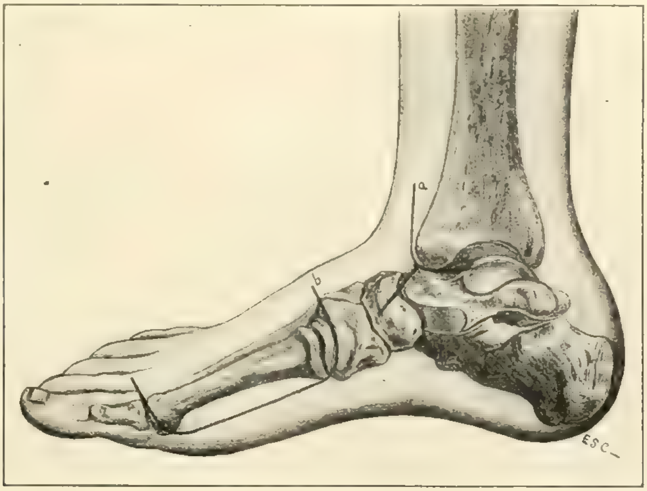


Fig. 255.—Excision of Os Calcis and First Metatarsal Bone. *a*, Ollier's inner incision for excision of the os calcis; *b*, excision of metatarsal bone of great toe.

tar arteries are ligated, and the flexor tendons are divided, in order that the toes may be extended at right angles to the dorsum. The sawed surfaces are brought together with chromicized catgut sutures, and the wound in the soft tissues is carefully closed. The extremity is then encased in a plaster-of-Paris splint and maintained in this position until healing is complete.

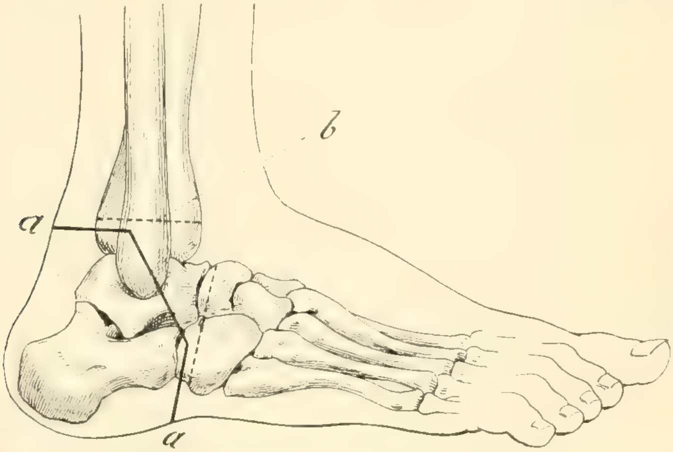


Fig. 256.—Wladimirow-Mikulicz's Osteoplastic Resection of the Tarsus. *aa*, Incision through the soft parts; *b*, *b*, saw-lines for division of the bone.

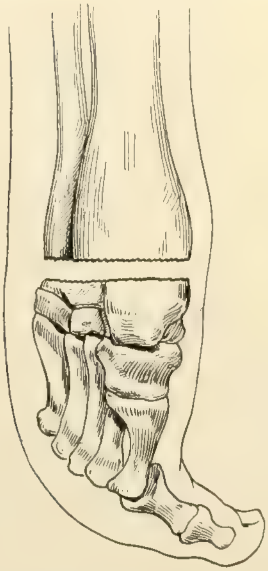


Fig. 257.—Wladimirow-Mikulicz's Osteoplastic Resection. Showing position of the foot after operation.

Results.—Kohlhaas has collected a total of 73 cases, and of this number 56 could stand and walk well.

Bryant states that in 19 operations, 13 of which were for tuberculous caries, 2 of the patients died of general tuberculosis eight months later; 12 made a good recovery and walked with more or less ease; and 5 experienced no benefit, 3 of them requiring subsequent amputation. He also states that the present high degree of usefulness and comfort which may be secured by prosthetic appliances lessens decidedly the utility of such methods of practice.

Excision of the Astragalus.—Excision of the astragalus alone is performed most frequently for an injury, such as a bad fracture (Fig. 258); for an irreducible dislocation of the bone forward; or for an irreducible dislocation of the tibia and fibula forward. The operation may also be necessary for talipes, for caries of this bone alone, or as a part of the operation for tuberculous disease of the ankle. The operation is best made through a combination of an outer and an inner incision—the outer in the manner suggested by Vogt (Fig. 253), the inner in that suggested by Ollier (*a*, Fig. 246). The outer incision begins in front of the external malleolus slightly above the ankle joint, extends downward and forward in a curved direction, and terminates at the base of the fourth metatarsal bone. The second incision extends downward and backward below the tip of the malleolus. The longitudinal incision is carried down between the tendons to the bone and opens both the ankle and astragalo-scaphoid joints. The anterior ligamentous attachments to the tibia and fibula, to the scaphoid, and to the os calcis are now divided by a knife or sharp chisel; the foot is strongly adducted, and the bone is pried forward with a periosteal elevator in order to expose the posterior ligamentous attachments.

This dissection is greatly facilitated by a second incision, the inner incision of Ollier. After the removal of the astragalus, the malleoli are placed in the proper position on the os calcis, and sutures are applied to the soft tissues.

The transverse incision recommended for tuberculosis of the ankle will also give excellent exposure and a good result in excision of the astragalus.

Excision of the Os Calcis.—The os calcis is frequently the seat of tuberculous and pyogenic disease, and may be extensively destroyed by injury; yet its double function of giving attachment to the tendo Achillis and of furnishing the posterior pillar of the arch of the foot, makes excision of this bone particularly undesirable. Every effort should therefore be made to save this support. As a rule, both tuberculous and pyogenic infections attack the centre of the bone, leaving a substantial shell, and the author has thus far been able, in every case treated, to avoid excision. Results have been particularly pleasing since the adoption of the method of bone-plugging with an iodoform mass, as described by von Mosetig-Moorhof (*vide antea*). By this method a cure of the disease and a complete repair of the defect may be accomplished without loss in the size of the bone. This operation can be performed through a short incision on the outer surface of the os calcis.

THE OPERATION.—When it is deemed wise to excise the entire os calcis, the operation is performed in the following manner: The foot is placed on its inner side on a sand bag, an incision extending down to the bone is begun at a point midway between the outer malleolus and the base of the fifth metatarsal bone, is carried backward in a direction parallel to the sole, and terminates at the inner border of the tendo Achillis. (Fig. 251.) Care should be taken not to injure the structures behind the inner malleolus. A second short incision may be made upward through the middle of the tendo Achillis. The plantar flap is dissected downward, the peroneal tendons are dissected out and held to one side, and the calcaneo-cuboid joint is opened. The astragalo-calcanean joint presents the main difficulties of the operation. This is opened from behind; then the bone is seized with a lion-jaw forceps and wrenched strongly backward and outward, to give room for the blade of the knife or chisel, which divides its strong fibrous attachments to the astragalus. The vessels on the inner side should be looked after with special care during the remainder of the dissection. When possible, the operation should be done subperiosteally. The wound is drained and closed in the usual way. Bryant states that about sixty-five per cent of these patients recover with useful limbs.

Excision of the Metatarso-phalangeal Joint of the Great Toe.—This operation finds frequent application in both disease and injury of this joint, and particularly in hallux valgus with secondary bunion. In the latter condition, excision furnishes the only satisfactory treatment. Amputation of the toe and excision of the bony prominences on the inner side of the head of the metatarsal bone have both been tried, but recurrence is very likely to follow.

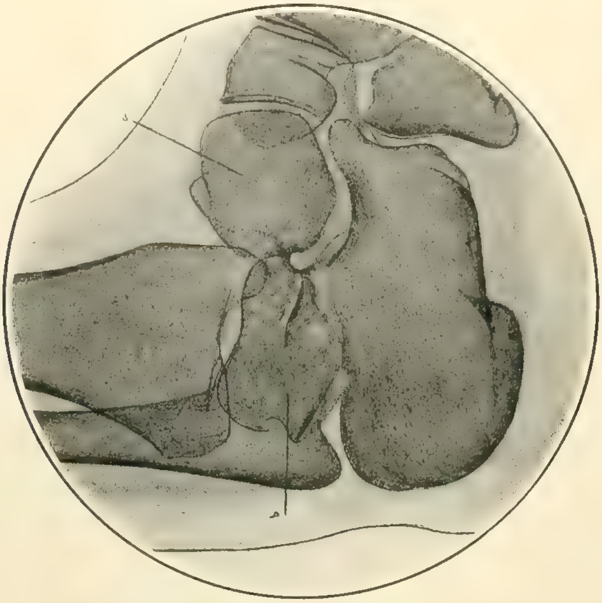


Fig. 258.—Fracture of Astragalus, Showing Fragments at *a* and *b*, as well as Marked Posterior Displacement Backward of Bones of Leg.

The Operation.—A longitudinal incision, two inches in length, is made along the inner side of the foot, exposing the articulation (*b*, Fig. 259). If a false bursa is present, this should be accurately dissected away before the joint is opened. The joint is now opened, and the head of the metatarsal bone, including the exostosis, is exposed subperiosteally. When this has been done, it will be found that the toe can be easily turned outward, and the head of the metatarsal freely exposed in the wound. A small metacarpal saw is now introduced, and the head of the bone is sawed off just behind the point of enlargement or (in the absence of enlargement) just behind the articular surface. (Fig. 259, *a*.) The sharp borders and any irregularities or additional exostoses are now pinched off with a rongeur, and the joint is carefully sponged. When the articular surface of the first phalanx is not diseased, it should be left, since a better result is thereby obtained. Drainage is provided for the joint, and the ligaments are united with catgut; the skin flaps are sutured with silkworm gut; and a splint is carefully applied. The dressing and the splint should be applied in such way that the toe shall be in line with the metatarsal, or slightly adducted, and its tip slightly elevated. Passive motion should be used at the end of two or three weeks, and the patient may be allowed to use the foot in one month. A pad of cotton between the great and the second toes will prevent any tendency to a recurrence of the hallux valgus. The functional results are excellent after this operation, both when done for deformity and when employed for the relief of suppuration.

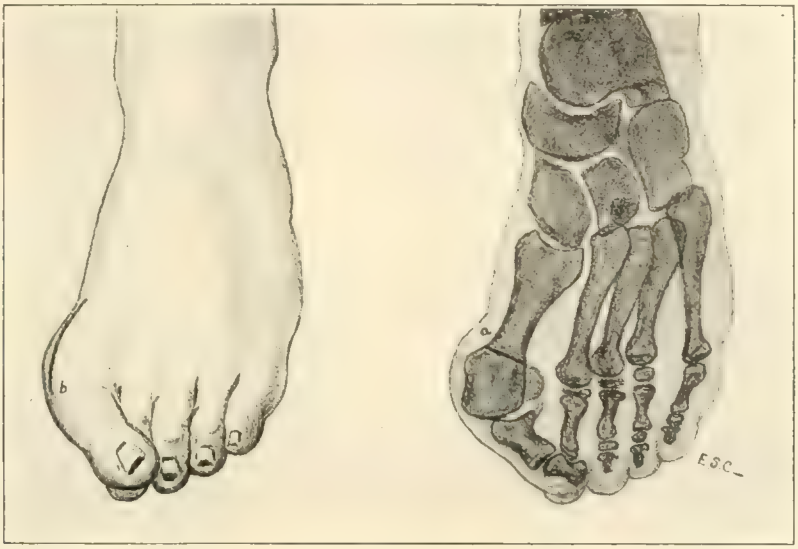


FIG. 259.—Excision of the Metatarso-phalangeal Articulation of the Great Toe. *a*, Line of bone section; *b*, skin incision.

The operation for the excision of other metatarso-phalangeal joints is almost identical with that described for the great toe. The dorsal tendons are readily pushed aside, and the difficulties arising from the deep location of the bone are overcome by the use of the Gigli-Haertel saw.

LIGATURE OF ARTERIES AND VEINS IN THEIR CONTINUITY.

By JOHN M. KEYES, M.D., New York City.

I. LIGATURE OF ARTERIES IN GENERAL.

Blood-vessels are ligated at their cut ends or in their continuity. By ligature of a blood-vessel in its continuity is effected, for some special purpose, the arrest of the circulation of the blood in that vessel.

The ligature of arteries was known to the ancients, although its use was uncommon. Celsus described it in the first century, Galen in the second, Antyllus in the fourth, Aëtius in the fifth, and Rhazes in the tenth. But to Ambroise Paré belongs the credit of establishing the universal use of the ligature. Paré's writings on this subject appeared in 1564, and he is rightfully styled the "Father of the Ligature." This important surgical proceeding was slowly accepted and the method known as the mediate ligature was employed. By this method the tissues surrounding the artery were included, and usually an accompanying vein or nerve was embraced. Deschamps, in 1797, insisted that the vessel should be definitely separated from all surrounding tissues. This constitutes the immediate method commonly practised to-day. Antyllus, in the year 340 A.D., operated on aneurisms by ligating the artery above and below the tumor. Anel, in 1710, ligated the brachial artery for traumatic aneurism in the bend of the elbow, passing the needle close to the proximal end of the tumor. John Hunter, in 1775, after careful experiments, ligated the femoral artery at some distance from the proximal side of a popliteal aneurism. Hunter's method proved revolutionary in the treatment of aneurism. Brasdor, in 1790, suggested the distal ligature method for the cure of aneurism. In 1798 Deschamps applied this method of ligature to the femoral artery for the cure of an aneurism of the femoral artery. The case ended fatally. Shortly afterward it was performed by Sir Astley Cooper for aneurism of the external iliac. The result here was also unsuccessful. In 1825 Wardrop first successfully performed Brasdor's operation in a case of carotid aneurism. In 1822 Wardrop suggested the ligature of one or two of the distal branches of the artery, and in 1827 he performed the operation for the first time for the cure of an aneurism of the innominate artery, ligating first the carotid and later the third portion of the subclavian.

General Indications for Ligating Arteries.

The general indications which call for the ligature of arteries in their continuity are the following: The proper control of the circulation in the main trunk of a vessel or from one of its branches at a distance from the point ligated; prospective hemorrhage distal to the site of an operation, as illustrated in ligature of the lingual artery in operations upon the tongue; and excessive blood supply in inoperable tumors and in angiomata and cirsoid and arterio-venous aneurisms. However, in cirsoid and inoperable tumors the effect is more or less transient.

In infected wounds complicated with hemorrhage, ligature of the bleeding vessel in its continuity outside of the infected site should be promptly done.

General Considerations.

The strictest aseptic precautions should be observed. The patient should be placed on a table of convenient height, and the part containing the vessel to be operated on should be so placed as to render the vessel to be ligated easy of access. It is usual for the surgeon to stand at the side of the body to be operated on, and to make the incisions from above downward when operating on the right side, and from below upward when operating on the left side. The assistant usually stands at the side opposite to the surgeon, where he can keep the parts free from blood as exposed and the edges of the wound retracted when necessary.

The following instruments are required in ligating arteries in their continuity: heavy and light scalpels, hæmostatic forceps, dissecting and toothed forceps, tenacula, wound hooks, retractors of various sizes and shapes (Fig. 261), sharp-pointed and blunt scissors both straight and curved, straight and laterally curved aneurismal needles (Figs. 264 and 265), a ligature-carrier, means of illuminating deep wounds, straight, curved, and Hagedorn needles, a needle holder, and suture material—catgut plain, iodized, and chromicized. Kangaroo tendon, because of its reliability and thickness, is useful in tying the large blood-vessels. Ballance and Edmunds have reported excellent results from the use of goldbeaters' skin, which is prepared from the peritoneum of an ox. Senn has recently recommended the use of narwhal, walrus, and whale tendons, claiming for them ready sterilization, reliability, and unusual length of strand. Ox aorta is occasionally employed. Silk, plain, and silk floss have their devoted adherents. Some surgeons, especially the Germans, use silk exclusively.

Guides for Incision and Locating Arteries.

Linear, muscular, and bony contiguous anatomical parts are useful guides, as are also the pulsations of arteries and the color of the vessels.

Linear guides are surface lines that run between indicated points and that denote the established courses of blood-vessels.

Muscular guides are the muscles themselves or their prominent borders which bear definite relations to the courses of the arteries. Due care must be exercised to determine whether the muscles used as guides are overdeveloped and also whether they have broader origins or insertions than is usual.

Bony guides are certain bony prominences which bear characteristic relations to the vessels.

Contiguous anatomical guides are the known relations that surrounding tissues bear to blood-vessels; as, *e.g.*, nerves, muscles, tendons, sheaths of vessels, etc.

The pulsation of an artery is a reliable guide, but due care should be used to ascertain that the pulsation is not transmitted from some contiguous artery by intervening tissues. Pulsation is not available as a guide in cases in which preliminary control of the circulation is used to make the field of operation bloodless. Such operations are done in the limbs, as a rule. In the preparation for applying a ligature the limb is elevated, the soft parts are kneaded toward the body, and an Esmarch tourniquet is applied proximal to the site of ligature. The clearer field obtained by exsanguination compensates somewhat for the loss of pulsation as a guide.

Finally, the color of the vessels aids, the arteries often being white or pinkish in appearance, and the veins purplish.

STEPS OF THE OPERATION.

The initial incision is usually made in the line of the vessel by inserting the point of the knife quite at right angles; then, with the knife slanting, the incision is made the required length, after which it is withdrawn, with the point as at the beginning of the cut. (Fig. 260.) The primary incision will thus be of uniform depth throughout. The centre of the incision should correspond to the part of the vessel where the ligature is to be applied. The deep fascia or aponeurosis is then divided throughout a shorter extent than is the skin, exposing the

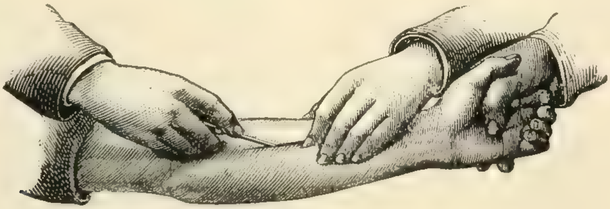


FIG. 260.—Incision of the Skin in the Operation of Ligaturing the Radial Artery. (After Farabeuf.) With his left hand the operator fixes the skin of the patient's forearm, while at the same time he presses firmly with the index finger over the course of the artery at the point where he wishes to begin his incision. Note the manner of holding the knife with the fingers of the right hand.

muscles or tendons beneath. The incisions should be clearly made and of sufficient length to afford a free field for further steps; and, when the vessel which is to be ligatured lies at some depth from the surface, the use of retractors (Fig. 261) will be required for keeping the edges of the wound widely separated. A gap between the muscles is then sought, and if it is occupied by fat we have what is known as the yellow line, if it is occupied by thickened fascia we have the so-called white line, to follow. At places we find an intermuscular artery. The intermuscular space is then freely divided in the direction of the other incisions but to a lesser extent, the separation being advanced either with the handle of the scalpel or with the finger. The incisions and separation, subsequently to the initial skin incision, should be made shorter and shorter through each succeeding tissue, so that the incision through the sheath of the artery represents the apex of an inverted triangle. The wound should be kept as free from blood as practicable and widely retracted, though at this stage it is of advantage to relax the parts, so as to be the better able to locate the vessels. The fingers are of great aid in differentiating the vessels. The arteries feel firmer than the veins, are more resilient, and when compressed they feel hollowed out, having margins thicker than the centre. The veins are soft and yielding, with thin walls, and when compressed they swell out at their distal ends. The nerves are hard, round, inelastic; they are of even contour and are made up of bundles parallel to the vessel and occupying more or less definite relations to it.

FIG. 261.—Farabeuf's Retractor.

The smaller arteries are usually accompanied by two veins, known as the venæ comites. The larger arteries, such as the carotid, iliac, femoral, popliteal, etc., have but one vein, which vein bears a definite relation to the artery. The venæ comites are usually located one on each side of an artery, and they communicate freely, behind and in front of the artery, with each other. Also there may be three or more veins accompanying an artery, in which case they are called "satellite veins." When there are three veins, the third one is usually in front of the artery. In the space between the tibialis anticus and the extensor communis digitorum muscles, where the intermuscular gap is antero-posterior, the artery is sometimes found with the veins before and behind it.

When the artery has been located, its sheath, or the thickened tissue surrounding it, is picked up by finely toothed forceps, and after one has ascertained that it is free from vessels and nerves it is opened. (Figs. 262 and 263.) The sheath, or thickened tissue, is usually lifted above the vessel by one or two forceps and divided longitudinally in the course of the vessel in that part of it which is lifted above the vessel. The incision is then completed by making it only long enough to permit the passage of the ligature around the artery. Before cutting into the sheath it is well to move it to and fro to insure its being free from attachments. After retracting the edges of the sheath and carefully exposing that part of the artery which is to be ligated, an unthreaded, blunt-pointed, curved aneurismal needle (Figs. 264 and 265) is passed around the vessel, away—as a rule—from the accompanying vessel, care being observed that no vein or nerve is included. The end of the needle appearing at the opposite side of the artery is threaded and withdrawn, leaving the ligature *in situ*. Some prefer to pass the needle threaded and then to withdraw it, leaving the ligature in place. It may be necessary to pass the needle toward the vein. When the ligature is in place it is tied with a knot at right angles to the long axis of the artery. The knot should be sufficiently tight to occlude the lumen of the vessel. In tying the knot due care must be exercised not to pull the vessel out of its bed, and this is best accomplished by making the ends of the index fingers (or the thumbs, as some prefer) meet over the artery, and by having the first pull of the ligature come with the terminal knuckles together, these latter serving as the fulcrums of the levers. (Fig. 266.)

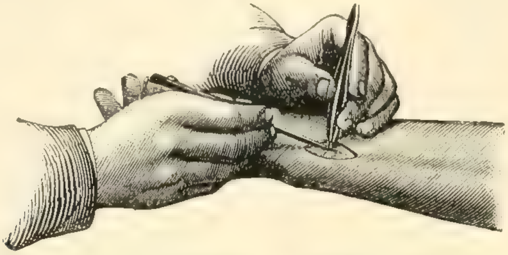


FIG. 262.—Laying Bare an Artery (the Radial, for Example): First Step, after the Skin has been Incised. (After Farabeuf.) The sheath of loose connective tissue surrounding the artery is picked up with the forceps and put slightly upon the stretch; and then, with the sharp point of the bistoury, a small longitudinal opening is made in this stretched tissue.

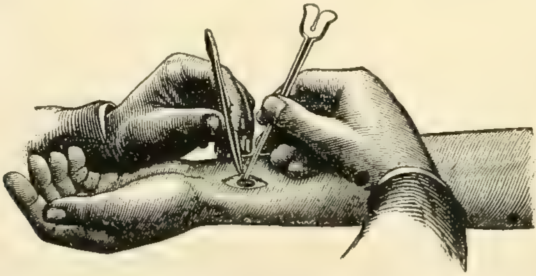


FIG. 263.—Laying Bare an Artery; Second Step. (After Farabeuf.) The surgeon, continuing to hold one edge of the opening in the sheath on the stretch by means of the forceps, introduces into the opening the beak of a grooved director.

In the third step, which it is unnecessary to illustrate, the surgeon passes the director beneath the artery, and gradually, by a to-and-fro movement, separates the wall of the vessel from the surrounding sheath of connective tissue throughout the desired extent. The passing of the curved end of the artery needle along the groove of the director, the setting free of the ligature with which the latter is armed, and the withdrawal of the artery needle are steps which present no difficulties.

The various knots commonly used are the reef, surgeon's, and Ballance-Edmunds knots. (Figs. 267 and 268.)

Most surgeons, instead of using the surgeon's knot, employ by preference a reef knot, often adding a third loop, which is tied lightly. This third loop prevents the ends from loosening. The ends of the ligature, after the completion of the knots, are cut off about one-fourth of an inch from the last tie.

The Ballance-Edmunds Stay Knot (Fig. 267).—This knot is used for securing the larger vessels, as the innominate, the common carotid, and the femoral. For this purpose silk floss, heavy chromicized catgut, and kangaroo tendon are the suture materials at present used. The material is applied by placing around the vessel two ligatures parallel to each other and close together, and by making on each separately the first hitch of a reef knot, which is tightened just sufficiently to close the lumen of the vessel without dividing the coats of it. Then by uniting together the ends of the ligature on either side the second hitch of the reef knot is made. By this method we get a broad surface approximation of the walls of the intima lending a large surface for endothelial proliferation, in consequence of which firm union should take place.

Several other styles of knots may be used in ligating vessels, but for all practical purposes the reef, surgeon's, and Ballance-Edmunds knots suffice.

The artery having been ligated, the wound should be thoroughly dried, the sheath closed with a fine continuous suture or with interrupted sutures. The intermuscular gap, if required, is obliterated with buried catgut sutures, and the external or superficial wound is closed by interrupted silkworm or catgut sutures. It is undesirable to drain the wounds; but where it cannot be avoided, rubber tissue serves the purpose best.

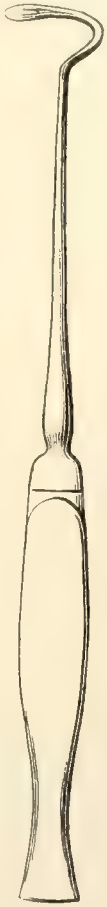


Fig. 264.—Dupuytren's Aneurism-Needle Carrier.

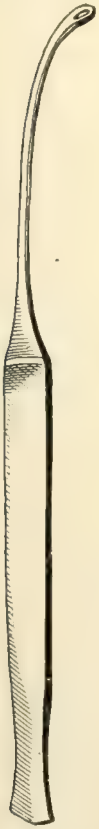


Fig. 265. — Syme's Ligature Carrier.

The after-treatment consists in keeping the part operated on at absolute rest, and in having it warm and the dressings perfectly aseptic. The arm when operated on should be outstretched upon a pillow, and the lower limb slightly raised on an inclined plane. Operations on the larger vessels require three weeks of compulsory rest. The lower limbs, when operated on, require more recumbent rest than do other parts where vessels have been ligated. The limbs should be wrapped in cotton batting and (when indicated) kept warm with hot bottles.

Complications, and Causes of Death After Ligature.

The more important consequent complications are: Shock; secondary hemorrhage; gangrene of a limb; and inflammation and suppuration at the seat of operation.

Shock is ordinarily of slight degree and therefore of little moment, except perhaps when associated with the ligation of a vessel supplying blood to an important viscus.

Secondary hemorrhage may be due to ulceration around the ligature from infection, especially if the vessel wall be diseased; to an imperfect clot dependent on the too close proximity of a collateral branch; or to such violent movements as those produced by severe coughing—movements which disturb repair or perhaps dislodge a poorly applied ligature.

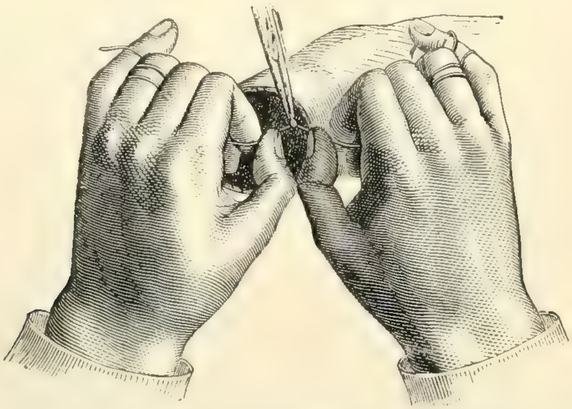


Fig. 266.—Shows the Proper Attitude of the Surgeon's Fingers at the Moment of Tightening the Ligature which has been Placed Around an Artery. (After Farabeuf.)

Gangrene is more apt to occur in the lower limbs, where the collateral circulation is poorer than in the upper extremity. It may set in within twenty-four hours or as late as eight days subsequently to the operation.

Inflammation and suppuration at the seat of operation are due to infection, incident to some defect in the operative technique, and they often lay the foundation for secondary hemorrhage. In such cases, only ligation of the vessel in sound tissue, at either side of the seat of hemorrhage, safely meets the demands of a dangerous situation. Religation in an infected wound is not permissible, as repeated hemorrhages, consequent exsanguination, and even death are thus invited. (For effects in ligation for aneurism, see the article on Surgery of the Heart and Blood-Vessels, in Vol. VII.)

TEMPORARY CONTROL OF THE CIRCULATION IN ARTERIES BY LIGATURE.

Temporary control is employed for the purpose of rendering a field of operation as bloodless as possible, and also in cases in which the vascularity of the part to be operated on is so excessive as to make hemorrhage dangerous. Instances of its use exist in amputations of limbs, in operations on the neck, in suturing wounds of blood-vessels, in certain cases of Matas' method of endoarteriorrhaphy, etc. The steps in the operation, up to the point where the ligation has to be applied, are identical with those already indicated for ligature of arteries. It is often sufficient to place a looped piece of broad silk or a blunt hook under the artery and to lift it up so that the kink produced will occlude the lumen of the vessel. It may become essential, in order not to block the field of operation, temporarily to ligate the vessel, and this is best done by tying the vessel slowly and steadily with a broad piece of tape so as not to injure its walls. The ligature is removed after the necessity for its use has ceased, and the further steps in the ligation are the same as those governing ligations in general. Where a loop or a broad hook is used to control the circulation in the artery, it is not necessary to open the sheath of the vessel.

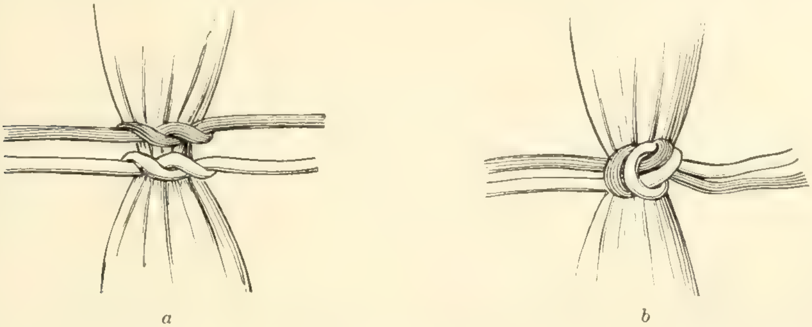


FIG. 267.—The Ballance-Edmunds Stay Knot, composed of two separate strands or ligatures of floss silk. At *a* the first hitch of the reef knot is shown, and at *b* the completed knot.

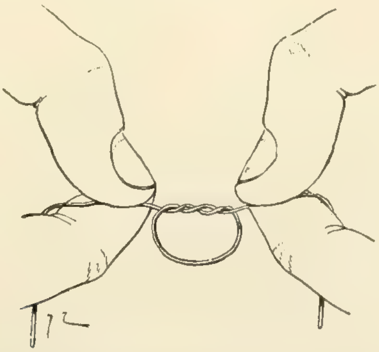


FIG. 268.—Surgeon's Knot. (After Lejars.)

(For information in regard to the materials that are suitable for ligatures, the methods of sterilizing them, etc., the reader is referred to Dr. Moore's article in Vol. I., p. 724 *et seq.*)

II. LIGATURE OF INDIVIDUAL ARTERIES.

The Innominate Artery.—Because of its high resulting mortality, ligature of this artery is seldom warranted. However, because of our radical measures and aseptic technique the percentage of recoveries is increasing. The artery was first ligated in 1818 by Dr. Valentine Mott, of New York. Death is usually the result of shock, or sepsis, or secondary hemorrhage. Brain complications, however, may cause death. Out of forty-three cases reported, seven were successful. The first successful case was that of Smyth of New Orleans; the patient lived ten years. In Burrell's case, in which the sterno-clavicular articulation and the upper end of the sternum were resected, the patient lived one hundred and four days, and then died of coexisting cardiac disease. Curtis' patient at the time of reporting, eleven months after operation, was still alive. One-third of all cases done under aseptic technique terminate in recovery. Resection of a portion of the sternum, etc., has added much indeed to the technique and security of the operation.

Surgical Anatomy.—It is the largest branch given off from the arch of the aorta. It arises on a level with the upper border of the second right costal cartilage from the commencement of the arch of the aorta in front of the left carotid artery and ascends obliquely to the upper border of the right sterno-clavicular articulation; then it divides into the right common carotid and the right subclavian arteries. The length varies from 3.8 cm. to 5 cm. (one and one-half to two inches).

Anteriorly, this artery is in close relationship to the manubrium, the origin of the sternohyoid and sternothyroid muscles, the remains of the thymus gland, the left innominate and the right inferior thyroid veins, and occasionally the inferior cervical branch of the right pneumogastric nerve; posteriorly, it is in contact with the trachea; on the right side it is in close relationship to the right innominate vein, the right pneumogastric nerve, and the pleura; and on the left side it is bounded by the remains of the thymus gland, the origin of the left carotid artery, the left inferior thyroid vein, and the trachea.

As a rule no branches are given off from the innominate. Occasionally the thyroidea ima or the thyroid (bronchial) branch is found.

Linear Guide.—There is no practical muscular or linear guide that indicates the course of this vessel. However, a line drawn from the centre of the sternum to the right sterno-clavicular articulation indicates its course beneath the sternum. It should not be forgotten that, in many instances, the vessel bifurcates below this point and, more rarely, above.

Operations.—*Mott's method* is performed entirely in the soft parts. The patient's head and chest being extended and the face turned to the left, the incision is made along the upper margin of the inner third of the clavicle and is carried as far as the centre of the episternal notch. Then a second incision is made from the inner end of the first along the anterior border of the sternomastoid muscle. Both incisions divide the fascia and platysma as well as the skin. The triangular flap thus outlined is freed from its attachments and laid back. Then the clavicular and sternal attachments of the sternomastoid muscle are divided and turned back. The fibres of the omohyoid muscle, which depress the hyoid bone, are divided or nicked, thus allowing the muscle to retract. The anterior jugular and the inferior thyroid veins are divided between ligatures. The original incision is carried through the deep cervical tissues until the sheath of the common carotid artery is exposed. The sheath of this vessel is then opened and the artery followed downward until the innominate is reached. To avoid the right innominate and the inferior thyroid veins, and the right pneumogastric nerve, care must be exercised, the needle being passed from the outer side. The veins and nerves are retracted after blunt dissection. When tying the ligature, one must be careful not to compress the right phrenic nerve.

As the chief source of danger is secondary hemorrhage, the right common and the right vertebral arteries should also be ligated. In order to avoid dead spaces where infection can take place, the wound should be as thoroughly closed as is possible and the parts kept in place by pressure.

Bardenheuer's method is especially adapted to cases in which large aneurisms are to be operated on, and when a bony route is selected. A vertical incision is made from the lower border of the larynx well on to the manubrium sterni. A transverse incision is made along the upper surface of the sternum over the inner third of both clavicles. The incisions are made through the skin, the superficial and the deep fascias. The transverse cut should be so made as to divide the sternomastoid, sternohyoid, and the sternothyroid muscles. Then the inner extremity of the left clavicle and the first left rib should be divided subperiosteally about half an inch from their sternal extremities. For dividing the bone, a Gigli saw, a rongeur, a bone-cutting forceps, or a chisel may be employed. The posterior surface of the manubrium having been freed of its periosteum, the bone itself is divided subperiosteally in a transverse direction about one centimetre ($\frac{2}{5}$ in.) below its superior border or at its attachment to the gladiolus; then, after it has been freed from its attachments, this piece of bone should be removed. The periosteum having next been split in the median line, the inferior thyroid vein is divided between ligatures; the left innominate vein is retracted and depressed, and the right innominate vein is also retracted. The ligature is passed around the artery, between it and the pleura, care being taken that the pleura be not punctured and that no nerves be included. The Ballance-Edmunds ligature is the best one to use. The right common carotid and the right vertebral arteries are ligated at the same time. Bardenheuer's operation was reported in the *Deutsche med. Wochenschrift*, 1885.

B. Farquhar Curtis, of New York, in the *Annals of Surgery* for October, 1901, reports using, for ligature of the innominate artery, a modification of Milton's method of exposing the anterior mediastinum. This method, as the accompanying photograph (Fig. 269) shows, leaves but little disfigurement and it affords ready access to the artery and the vein. As only two cases in which this method was used have thus far been reported, its more or less general adoption will depend on the results of further experience.

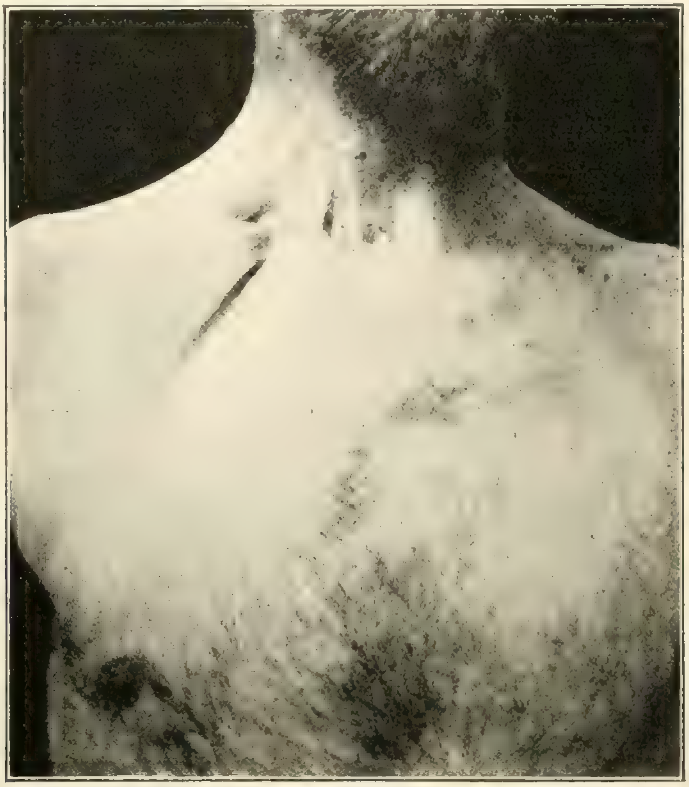


Fig. 269.—Photograph of Dr. Curtis' Patient, Showing Scars of Milton's Operation for Ligating the Innominate Artery. In this operation the clavicle is temporarily divided. (*Annals of Surgery*, **Oct., 1901.**)

Operation. (Figs. 270 and 271.) A median incision dividing the skin and the deep fascia above, and the periosteum below, is made. The incision runs from the cricoid cartilage of the larynx to the middle of the sternum. The soft parts at the base of the neck are widely separated. The periosteum of the manubrium is divided transversely along its upper border, and the periosteum and the muscles on the posterior surface of it are dissected free as far as blunt periosteal elevators and the fingers can reach. The bone is divided through the vertical incision by an ordinary saw, care being taken to protect the soft parts of the neck and the soft parts behind the sternum by the use of flat metal strips. The saw is directed from below upward, and it is managed in such a manner as to divide the bone entirely above, but only partially below; at the inferior end of the incision it simply grooves the bone. A short chisel is then used to force the thin layer of bone on the posterior surface to give way. With the skin well retracted a transverse incision is made through the periosteum at the level of the first and second intercostal spaces, and then the bone is divided obliquely outward from the middle by means of a chisel. The two halves are strongly pulled apart by heavy retractors, thus exposing the periosteum on the posterior aspect of the bone. After this membrane has been incised, the two halves of the bone may be further retracted, the gap thus created measuring from one to two inches in breadth. In the median line the muscles and the deep fascia are divided (beginning above) by blunt dissection or by means of forceps and scissors. The veins are divided between ligatures as they are encountered. The trachea and the great vessels at the root of the neck are freely exposed. Finally, the innominate artery should be cautiously isolated and tied with doubly heavy ligatures. The walls of the vessel may be folded within the loop of the ligature, so that they may escape being crushed. The ligation should be broad and so tied as not to cause any uneven pressure, especially from the knot.

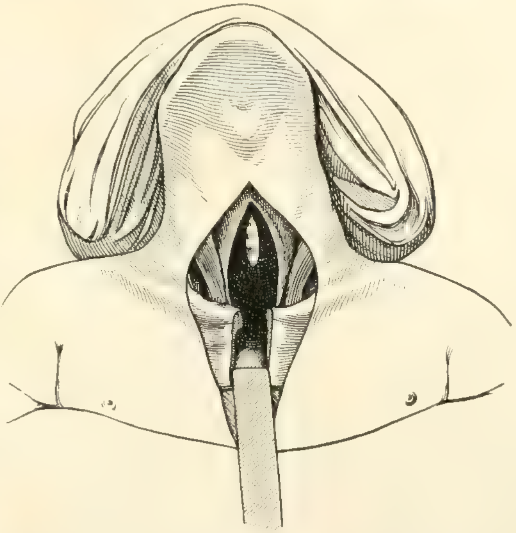


FIG. 270.—First Stage of Dr. B. Farquhar Curtis' Operation for Ligature of the Innominate Artery. Bone divided and retracted, showing the sternohyoid muscle and the posterior periosteum of the manubrium. The trachea may be seen through a small incision between the muscles. (*Annals of Surgery*, Oct., 1901.)

In 1859 Dr. E. S. Cooper, of San Francisco, Cal., first resected the upper part of the manubrium and the right sterno-clavicular articulation in order to expose the artery. The preliminary steps are practically the same as those described in the preceding operation. After the soft parts in front have been retracted and the large veins behind have been protected by means of a spatula placed posteriorly to the sternum, the right sterno-clavicular articulation, the sternal end of the first rib, and the upper portion of the manubrium are removed. The removal should be accomplished by means of a Gigli saw, a chisel, and a rongeur, or by bone-cutting forceps. The further steps in this operation are practically the same as those in the oblique method.

Ligation by Splitting the Manubrium Sterni.—In this method the manubrium is divided both transversely and vertically without loss of bone.

Operation.—A transverse incision, curving downward at its central portion, should be made from the inner third of the anterior surface of one clavicle to the inner third of the anterior surface of the other clavicle. It should cross the manubrium at the level of the junction of its upper and middle thirds. The soft parts are all divided through this incision down to the bone. Bleeding points as encountered are ligated. The manubrium is freed subperiosteally downward to the junction of the manubrium and the gladiolus and upward as far as the episternal notch. After the upper border is freed, the posterior aspect of the manubrium should be cleared subperiosteally as low down as it has been anteriorly. The overlying soft parts on the anterior surface are retracted, and the manubrium is divided transversely at the junction of the upper borders of the second ribs and also vertically through its centre. The bony incisions are best accomplished by means of either a Gigli-Haertel saw or by bone-cutting forceps. The two divided halves should be well retracted laterally, and the posterior periosteum incised. The overlying soft structures are displaced to the left, and the inferior thyroid veins are ligated and divided. This process exposes the innominate veins. The left innominate vein should be depressed, and the right innominate vein should, if practicable, be displaced forward and to the right side. Then, after carefully noting the relations of the important nerves and the pleura, the operator should clear the innominate artery, guarding the right pneumogastric artery and the pleura. It is then time to pass the ligature between the artery and the pleura, placing it as far from the aorta as is practicable.

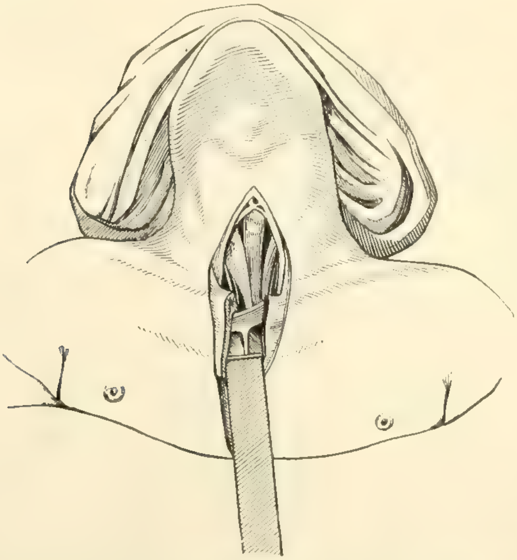


Fig. 271.—Second Stage of Dr. Curtis' Operation. (See Fig. 270.) Full exposure of the trachea, innominate artery, arch of the aorta, and the left innominate vein crossing the latter. The right pneumogastric and the recurrent laryngeal nerves are seen, the latter originating unusually low in this subject. (*Annals of Surgery*, Oct., 1901.)

The operation need not be carried out subperiosteally. The periosteum can be divided along the bony incisions. By this method less contusion of the tissues is caused and much time is saved.

Ligation by Oblique Incision.—The position of the patient and the landmarks are the same as those mentioned in the description of Mott's operation (see page 477). The incision begins at the junction of the middle and lower thirds of the anterior border of the sternomastoid muscle. It passes along the lower third of the margin of the muscle and then sweeps over the upper edge of the episternal notch on to the manubrium. The skin, superficial fascia, platysma, and deep fascia are incised. The anterior jugular vein and the transverse branch between the two anterior jugulars are ligated between ligatures and divided. The sternomastoid muscle is drawn outward and its sternal attachment is divided if necessary. The sternothyroid and the sternohyoid muscles are drawn inward and, if necessary, their sternal attachments may be divided. The deep cervical fascia covering the carotid sheath is divided, the sheath is opened, and the common carotid artery is followed, behind the sternoclavicular articulation, as far as to the subclavian and then to the innominate arteries. Watchfulness is required if the recurrent laryngeal nerve, which lies behind the sheath, is to escape injury. After the inferior thyroid vein has been ligated the innominate should be exposed, care being taken to avoid the left innominate vein in front and the right pleural behind. The common carotid and vertebral arteries should also be tied through this same incision.

General Considerations.—Rigid asepis should attend each step of these operations. When the wounds are closed, it is desirable to approximate as closely as possible the divided surfaces. Dead spaces are best avoided by the use of graduated compresses. Drainage should not be employed unless absolutely necessary; and then it is to be obtained by a rubber-tissue or a textile-fabric drain. The pain and irritability of the patient consequent upon the operation should be relieved by hypodermic injections of morphine.

The choice of the method to be used in ligating the innominate depends upon the indications and upon the extent of the diseased condition. In aneurism, for instance, the relations of the parts may be materially changed, and a bony route is then to be preferred, as it gives room for free manipulation and allows the operator to observe the changed relations caused by the tumor.

It should be remembered that if the innominate is shorter than usual the lower extremity of the common carotid may be tied instead; also that, if the aorta arches to the right, the innominate will be found on the left instead of on the right side.

The Common Carotid Artery.—Ligature of this artery is indicated by a variety of conditions. Occasionally, as an emergency measure, both common carotids have been ligated simultaneously.

SIMULTANEOUS LIGATURE.—The simultaneous ligature of both common carotids should be avoided, as it is invariably followed by fatal coma. Two weeks at least should intervene between the two operations, and even then death may follow. Simultaneous ligature and ligature performed at intervals of time of varying length have been done about forty times. The shortest interval followed by recovery was four and a half days. In the other instances of recovery reported the intervals varied from thirteen to thirty-five days.

The vessel was first ligated for hemorrhage by Abernethy in 1798; the result was fatal. Fleming, in 1803, performed the operation with success. Sir Astley Cooper, in 1805, first ligated it for aneurism. His patient died. In 1808, however, he was successful with a similar case.

Temporary Ligature.—Temporary ligature is resorted to for the arrest of hemorrhage from the branches without exposing the patient to the brain complications which may arise from permanent closure of this artery. It is also resorted to, with much economy of time and blood, in extensive operations in regions supplied by the vessel or its branches. The artery is exposed by the usual methods, is encircled by a piece of tape, and lifted up so as to shut off its lumen. It may also be tightened sufficiently by a broad ligature to close its lumen without injuring the coats of the vessel.

Relations of the Right Common Carotid Artery in the Lower Part of the Neck.—This artery arises from the innominate artery behind the right sternoclavicular articulation, passes upward, outward, and slightly backward to the upper border of the thyroid cartilage, where it divides into the external and internal carotids. The common carotid bifurcates sometimes higher up than the upper border of the thyroid cartilage, indeed not infrequently at the level of the angle of the jaw. It is also known that the common may not divide at all, and that the lingual, facial, etc., arise from the common trunk. The former condition (higher bifurcation) exists in about fifteen per cent of instances. The artery is contained in a sheath with the pneumogastric nerve and the internal jugular vein, each being separated from the other by a fibrous septum. The vein lies to the outer side and slightly overlaps the artery; the nerve is posterior to and between them. For surgical purposes the artery is divided, opposite the lower border of the cricoid cartilage, by the omohyoid muscle, into a lower and deeply seated part and a superficial and upper part. Its length is 9.5 cm. (three and three-quarters inches).

Relations of the Left Common Carotid Artery in the Lower Part of the Neck.—This artery arises from the highest part of the arch of the aorta, passes upward and outward, overlapped by lung and pleura, in front of the trachea to the left sternoclavicular articulation, where it resumes about the same relations to its contiguous parts as does the right carotid to its parts. It length is 11.5 cm. (four and three-quarters inches).

Relations of the Left Common Carotid within the Thorax.—*Anteriorly*, it is separated from the sternum by the sternohyoid and the sternothyroid muscles, the left innominate veins, and the remains of the thymus gland; *posteriorly*, it lies on the trachea, œsophagus, and thoracic duct; *internally*, it is in relation with the innominate artery, the inferior thyroid veins, and the remains of the thymus gland; *externally*, it is in relation with the left pneumogastric nerve and the left pleura. The left subclavian artery is slightly external and posterior to it.

Relations of Both Common Carotids in the Upper Part of the Neck.—*Anteriorly:* skin, superficial and deep fascias, platysma, sternomastoid, sternohyoid, sternothyroid, and omohyoid muscles, descendens and communicans hypoglossi nerves (the descendens is sometimes found within the sheath, but generally upon it), sternomastoid artery, superior thyroid, middle thyroid, and anterior jugular veins. *Posteriorly:* pneumogastric nerve, recurrent laryngeal nerve, inferior thyroid artery, longus colli and the rectus capitis anticus major muscles.

Linear and Muscular Guides.—The linear guide is a line drawn from the sternoclavicular articulation to a point midway between the angle of the jaw and the tip of the mastoid process. (Plate XXIX, Fig. 1.) The muscular guide is the anterior border of the sternomastoid muscle.

Ligature of the Common Carotid below the Omohyoid Muscle.—The patient should be placed on the back with the shoulders slightly elevated, the face turned to the opposite side, and the chin extended. The incision, about three inches in length, is made along the anterior margin of the sternomastoid, extending from just above the level of the cricoid cartilage to a point just above the sternoclavicular articulation. The skin, superficial fascia, platysma, and the deep fascia are divided, thus exposing the anterior border of the sternomastoid muscle. If the sternomastoid artery is to be divided it should first be ligated; if it is not divided, it, with the thyroid vein, should be pushed aside. The sternomastoid muscle is retracted outward, a relaxed state of the muscle aiding the retraction; and the sternohyoid and the sternothyroid are retracted inward. The two latter muscles may be divided when necessary. When these muscles are retracted the lower border of the omohyoid will be seen above. The fascia beneath these muscles is divided, and the divided edges are drawn apart, when the descendens noni will be found on the inner border of the common sheath. In the common sheath the artery lies internal to the vein, and the pneumogastric nerve is between the vessels and posterior to them. The artery within the sheath should be carefully located, and a part of the sheath just over the artery should be picked up with thumb forceps or tenacula and incised. The edges of the incision are held apart and the needle is passed from without inward between the artery and the sheath, due care being observed to see that the vein, pneumogastric or recurrent laryngeal nerves are not injured.

Ligature of the Common Carotid above the Omohyoid Muscle. (Plate XXIX, Fig. 1.)—The linear and muscular guides are the same here as those given for the previous operation. The neck should be prominent, the head extended, and the face turned toward the opposite side. The incision is three inches long with the centre at the cricoid cartilage. The cut is made through the skin, superficial fascia, platysma, and deep fascia, the small vessels being avoided as much as possible. The sternomastoid is retracted outward. The omohyoid muscle is exposed and retracted downward, or cut if necessary. The artery is superficial here and easily found. The sheath is opened from the inside, care being taken to avoid the descendens hypoglossi nerve and the internal jugular vein. The needle should be passed from without inward, care being taken to avoid the internal jugular vein and the pneumogastric nerve.

The collateral circulation takes place by way of the inferior and superior thyroid arteries, the profunda cervicis and the occipital artery, the transversalis colli and the occipital arteries, and the vertebral artery and the circle of Willis.

The dangers of these operations are great. Of the total number of cases reported before the aseptic period, thirty per cent ended fatally. With improved technique and thorough aseptic precautions the percentage of mortality has been materially lessened. Dangers arise from the failure due to thrombosis, from sepsis, from secondary hemorrhage, and from the sudden shutting off of the blood supply to the brain. If the collateral circulation is quickly established, and if the vessels concerned are elastic enough, a good result may be expected; but where the circulation is slowly established and where the vessels are inelastic, as in arteriosclerosis, the results are likely to be unfortunate. The sudden shutting off of the circulation may lead to softening of the brain; we may have white ischæmic necrosis or yellow hemorrhagic softening. With white ischæmic necrosis we have a total shutting off of the blood supply, due to thrombosis or embolic occlusion of the peripheral vessels. Yellow necrosis occurs where the arterial anæmia is accompanied by venous congestion with attendant hemorrhage and traumatism. This may be followed, as the circulation is being slowly restored, by hemiplegia, which, as a rule, gradually disappears. Accidental inclusion of the vagus in a ligature or clamp may cause various symptoms related to the heart and respiration, but these symptoms are relieved by prompt release of the nerve. Temporary arrest of the circulation before final ligature may enable the surgeon to form a reasonable estimate of the outcome of the final act so far as the effect on the brain is concerned. Division of the pneumogastric nerve would lead to paralysis of the vocal cords on the side on which the operation was performed.

General Considerations.

The ligation of the right common carotid is required more frequently than is the ligation of the left. The ligation of the left is more difficult than is the ligation of the right because of the intimate relation which it bears to its internal jugular vein. If the artery bifurcates at or below the cricoid cartilage, both of its branches should be secured. Such bifurcation is, however, very rare. In cases of hemorrhage from its terminal branches ligature of the common carotid will not be effectual because of the free communication of these vessels at the point of bifurcation of their parent trunk, and because of the readily established

EXPLANATION OF PLATE XXVIII.

Exposure of Arteries for Purposes of Ligation.

FIGURE 1.

External Carotid Artery. (After Leser.)

a, Angle of the lower jaw; *b*, hypoglossal nerve; *c*, external carotid artery; *d*, external jugular vein; *e*, common jugular vein; *f*, sternocleidomastoid muscle.

Subclavian Artery above the Clavicle. (After Leser.)

g, external jugular vein; *h*, phrenic nerve; *i*, subclavian artery; *k*, brachial plexus; *l*, subclavicular nerve.

FIGURE 2.

Femoral Artery below Poupart's Ligament. (After Zuckerkandl.)

In the upper exposure, in the median line, are seen the femoral artery and, internal to it, the femoral vein.

Below, the artery and vein hold the same relations as above.

s, Sartorius muscle; *f*, fascia lata.

FIGURE 3.

Radial and Ulnar Arteries. (After Leser.)

a, Superficial fascia, underneath which are seen the tendons of the supinator longus and the abductor pollicis brevis muscles; *b*, radial artery; *c*, tendon of the flexor carpi radialis muscle; *d*, ulnar nerve; *e*, ulnar artery; *f*, flexor carpi ulnaris; *g*, flexor sublimis digitorum.

FIGURE 4.

Popliteal Artery. (After Leser.)

a, Posterior tibial nerve; *b*, popliteal vein; *c*, gastrocnemius muscle; *d*, popliteal artery.

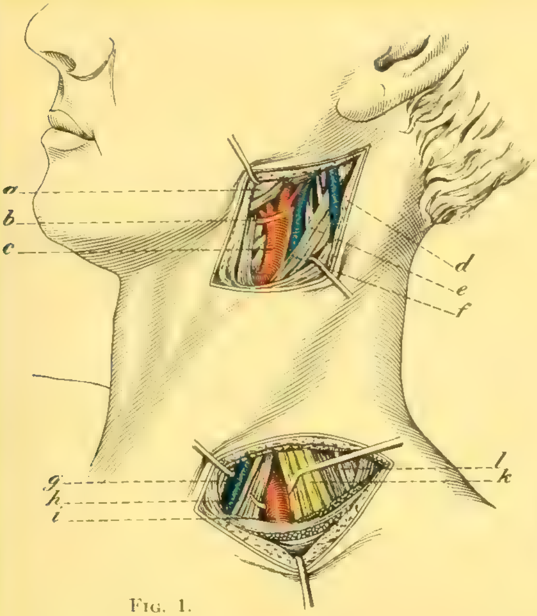


Fig. 1.

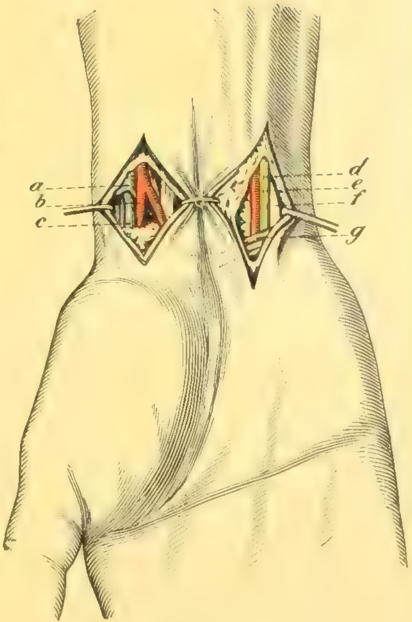


Fig. 3.

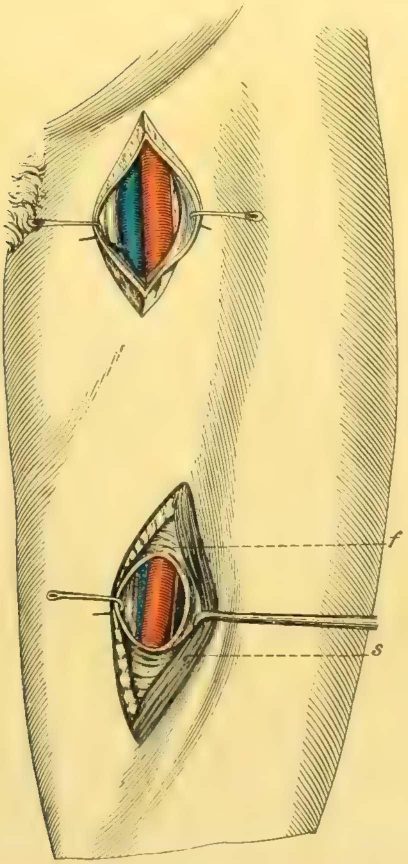


Fig. 2.

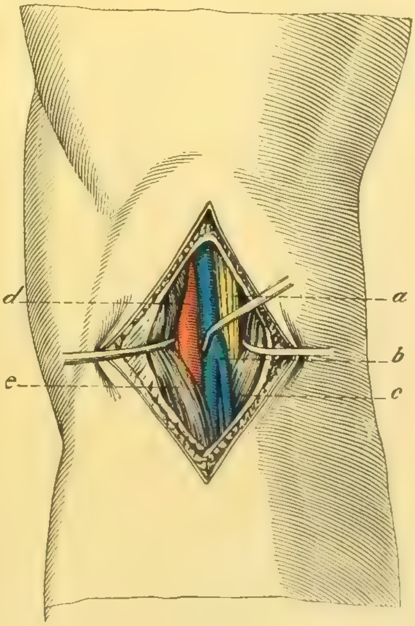


Fig. 4.

DISSECTIONS EXPOSING VARIOUS ARTERIES FOR LIGATION.

(Arteries in red, veins in blue, and nerves in yellow.)

collateral circulation from the opposite side. In these ligations also the following conditions may each contribute more or less to the difficulties of the operation: The respiratory movements of the tissues of the neck; inflammatory processes; dilated veins; overlapping thyroids; morbid growths; and either a too narrow or a too broad mastoid. If any branches be given off from the common carotid close to the part to be ligated, they also should be secured.

External Carotid Artery.—This was first ligated by Busch in 1827 for cirsoid aneurism. About one hundred and fifty cases were reported prior to the aseptic period, of which one in seven resulted fatally. Under aseptic technique the ratio has improved and stands now at one to thirteen.

Surgical Anatomy.—The external carotid artery arises opposite the upper border of the thyroid cartilage, ascends upward and forward, and then inclines backward to the space between the external condyle of the lower jaw and the external auditory meatus, where it divides in the parotid gland into the temporal and internal maxillary arteries. Its length is about 6.3 cm. (two and one-half inches). The common trunk of the thyroid and lingual veins crosses the vessel at the point where it is commonly tied.

The relations of the artery are as follows (Fig. 272): *Anteriorly:* skin, superficial fascia, platysma, deep fascia, hypoglossal nerve, lingual and facial veins, stylohyoid muscle and the posterior belly of the digastric muscle, branches of the facial nerve, and the parotid gland; *posteriorly:* parotid gland, internal carotid artery, superior laryngeal nerve, styloglossus and stylopharyngeus muscles, glossopharyngeal nerve, stylohyoid ligament; *internally:* hyoid bone, pharynx, superior laryngeal nerves, parotid gland, ramus of jaw; *externally:* internal carotid artery.

The linear and muscular guides are the same as those of the common carotid artery.

Operation Below the Digastric Muscle. (Plate XXVIII, Fig. 1.)—The incision is made a little in front of the sternomastoid muscle, and extends from the angle of the jaw to the level of the cricoid cartilage; the layers common to the neck are incised; after which it is important to locate the posterior belly of the digastric muscle which crosses the external carotid about 3.2 cm. (one inch and a quarter) above its origin, the hypoglossal nerve which crosses the artery below the origin of the occipital artery, and the tip of the great cornu of the hyoid bone. The facial and thyroidal veins should be retracted downward and the hypoglossal nerve upward. The internal carotid artery and the internal jugular vein should also be retracted upward. The needle is passed from the internal carotid, care being taken to avoid the superior laryngeal artery behind. The artery can be ligated at any point in its course, but it is by preference ligated between the lingual and the superior thyroid arteries. The vessel may be ligated above the posterior belly of the digastric also. The preceding method, however, should be selected whenever possible.

Dangers from the operation are slight when it is performed with aseptic technique. Sepsis and secondary hemorrhage may possibly result.

Through the same incision the superior thyroid, lingual, facial, occipital, and ascending pharyngeal arteries may be ligated.

Operation Above the Digastric Muscle.—The position of the patient is the same as for ligature of the common carotid. The linear guide is also the same in the two operations. The incision should extend from the lobule of the ear along the anterior border of the sternomastoid to the greater cornu of the hyoid bone, care being taken to avoid the parotid gland. Skin, superficial and deep fascia are divided; the anterior border of the sternomastoid should be retracted outward, and, after the posterior belly of the digastric has been exposed, it and the stylohyoid should be pulled downward, and partially or entirely divided if necessary. The parotid gland should be displaced upward and forward, and, if the jugular vein should be in the way, it should be retracted outward. The artery should be cleared and the ligature applied to the vessel before it enters the substance of the parotid gland.

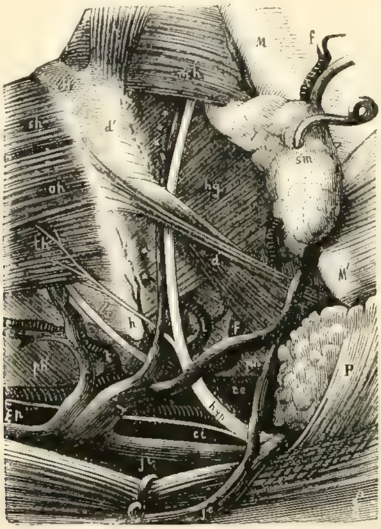


Fig. 272.—Relations of the External Carotid and Lingual Arteries of the Left Side. (After Farabeuf.) The picture shows the parts as they appear when the patient is lying down, ready to be operated upon. *M*, Inferior border of the jaw; *M'*, angle of the latter; *H*, hyoid bone; *h*, greater cornu of the same; *sh*, *oh*, *th*, respectively, the sternohyoid, omohyoid, and thyrohyoid muscles; *ph'*, inferior constrictor of the pharynx; *ph*, middle constrictor of the pharynx; *d*, posterior belly of the digastric muscle; *d'*, pulley-like band of cervical fascia belonging to this muscle; *hg*, hyoglossus muscle; *mh*, mylohyoid muscle; *P*, lower part of parotid gland covered by the aponeurotic expansion of the sternomastoid muscle; *sm*, submaxillary gland pulled to one side by a hook; *je*, external jugular vein; *ji*, internal jugular vein and its affluent branches, exposed to view by pulling to one side the sternomastoid muscle; *hyp*, loop of the hypoglossal nerve; *ls*, superior laryngeal nerve; *cp*, primitive carotid artery; *ci*, internal carotid; *ce*, external carotid; *t*, superior thyroid artery; *l*, lingual artery; *f*, facial artery. * *, Point where the lingual artery may be ligatured close to its origin. At this point, which is situated above the greater cornu of the hyoid bone, between the latter and the hypoglossal nerve, the vessel lies beneath the hyoglossus muscle. * * *, Point where the lingual artery, still lying beneath the hyoglossus muscle, may be ligated in its triangle, at a considerable distance from its point of origin.

General Considerations.—In ligating this vessel, especially at the lower part, care should be taken not to include the internal carotid. If it should thus be included, the fact may be ascertained in the following manner: After the ligature is placed, and before tying, raise the vessel upward out of its bed sufficiently by means of the ligature to ascertain the effects of the traction on the respective vessels, thus judging whether one or both are included. Also see that the ligature is applied at a proper distance above the bifurcation as well as sufficiently far below superior branches. The branches which are too near the seat of ligature should be tied independently with fine catgut. Thus, a space half an inch broad at either side of the proposed seat of ligature can be provided for the purpose of secure occlusion. When enlarged lymph nodes are encountered during the exposure of the vessel, they should be pushed aside or removed. Normally, a node of considerable size rests on the point of bifurcation.

Lingual Artery.—This artery was first ligated by Pirogoff in 1836.

Surgical Anatomy.—The lingual artery arises from the external carotid, a little below the greater cornu of the hyoid bone; it passes obliquely upward and inward and then curves downward and forward, forming a loop which is crossed by the hypoglossal nerve. Passing beneath the digastric and stylohyoid muscles it runs horizontally forward beneath the hypoglossal muscle; then finally ascending almost perpendicularly to the tongue it turns forward on the under surface of this organ and continues as far as the tip under the name of the ranine artery.

Guide.—The vessel has no superficial muscular guide, but it can be located by drawing a line parallel to and just above the greater cornu of the hyoid bone, which cornu can be readily made prominent by pressure on this bone at the opposite side of the neck.

Operation at Its Point of Origin.—The method used for exposing the external carotid below the digastric muscle is employed. The lingual artery is identified by its peculiar course. (See Surgical Anatomy and Figs. 272 and 274.)

Operation at the Place of Election (Fig. 273).—The patient is supine, the neck placed on a pillow, the face turned toward the opposite side, and the chin extended. A curved incision is made from the angle of the jaw down to the greater cornu of the hyoid bone and up to or near the symphysis menti. The incision goes through and includes the deep fascia attached to the hyoid bone. The flap, which carries the submaxillary gland with it, is laid back. The digastric muscle, the hypoglossal nerve, and the lingual vein are retracted upward with blunt hooks. The stylohyoid muscle may encroach on the triangle, and if it does the posterior fibres should be divided. The hyoglossus muscle is divided and turned upward, exposing the artery, which usually bulges out into the space. It should be traced backward so that it may be ligated on the proximal side before the dorsalis linguæ is given off. The needle is passed from above downward.

The submaxillary fascia and the fibres of the hypoglossus may be reunited if considered necessary.

With aseptic technique the operation is devoid of danger. In cases of hemorrhage of the tongue, or when the ligature is made as a preliminary to excision of the tongue, both arteries must be ligated.

Facial Artery.—This artery arises a little above the lingual artery and passes obliquely upward beneath the digastric and stylohyoid muscles and frequently beneath the hypoglossal nerve; it then runs forward under cover of the body of the lower jaw, being lodged in a groove on the posterior surface of the submaxillary gland; curving upward over the body of the jaw at the anterior inferior angle of the masseter muscle, it passes upward and forward across the cheek to the angle of the mouth, then upward along the side of the nose till it terminates at the inner canthus of the eye, under the name of the angular artery.

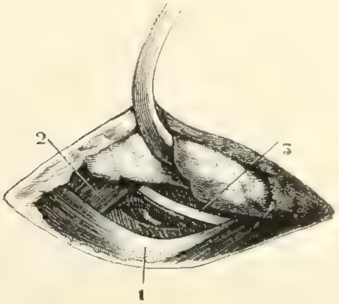


FIG. 273.

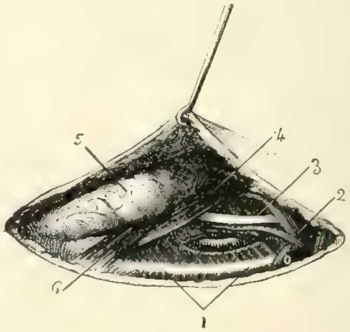


FIG. 274.

FIG. 273.—Ligature of the Lingual Artery (Left Side) in the Little Triangle, above the Tendon of the Digastric Muscle. (After Farabeuf.) Everything that might obstruct the view has been carefully dissected away and the submaxillary gland has been lifted up out of the field of operation. 1, Tendon of the digastric muscle still adherent to the hyoid bone; 2, mylohyoid muscle; 3, hypoglossal nerve. In the triangle the hyoglossus muscle has been incised, and through the opening the lingual artery may be seen.

FIG. 274.—Ligature of the Lingual Artery (Left Side) above the Greater Cornu of the Hyoid Bone. (After Farabeuf.) The field of operation having been cleared by a careful dissection, the following parts may be distinguished: 1, Greater cornu of the hyoid bone; 2, venous trunk made up of the thyroid, lingual, and facial veins; 3, hypoglossal nerve; 4, posterior belly of the digastric muscle; 5, submaxillary gland; 6, point of insertion of the stylohyoid muscle. The buttonhole-like opening in the keratoglossus portion of the hyoglossus muscle permits a view of the lingual artery.

OPERATION AT THE RAMUS OF THE JAW.—The vessel is well exposed by an incision under cover of the lower border of the ramus of the jaw, with the anterior border of the masseter muscle as the centre of the incision. After the deep fascia has been incised the artery usually comes into view. The vein lies posterior to the artery, and the ligature is passed from behind forward, in such a manner as to avoid the branches of the facial nerve. In cases in which it is necessary to tie the artery at its origin, the incision is the same as that for exposing the external carotid below the digastric muscle.

RESULTS.—These are uniformly good.

Superior Thyroid Artery.—This was first ligated by Charles Bell in 1814.

Surgical Anatomy.—The superior thyroid artery is the first branch of the external carotid, though it may arise by a common small trunk, together with the lingual and facial, from the common carotid, or may, and not infrequently does, arise at the bifurcation of the latter vessel. It follows a course inward and outward, going under the omohyoid, sternohyoid, and sternothyroid muscles to the upper part of the thyroid gland. Its vein and the superior laryngeal nerve are posterior to it, the nerve being in close relation.

Operation.—This is practically the same as that for the ligation of the external carotid artery. Special care should be taken to guard the superior laryngeal nerve. The ligature is applied before the hyoid branch is given off.

Results.—These are excellent.

Occipital Artery.—The posterior branch passes backward and upward to the space between the transverse process of the atlas and the mastoid process of the temporal bone, horizontally backward in the occipital groove, and finally upward into the scalp, coursing midway between the mastoid process and the external occipital protuberance.

Operations for Ligature at the Point of Origin.—In all essential respects the technique is the same as that employed for ligation of the external carotid artery below the digastric muscle. Locate the posterior belly of the digastric, and, just below it, will be found the hypoglossal nerve winding around the occipital artery. The relations of the nerve and vessel are rarely changed.

Operation Behind the Mastoid Process.—The artery is located by an incision, about two inches in length, that begins at the tip of the mastoid process and extends backward toward the occipital protuberance. Divide the skin and the attachments of the sternomastoid and the splenius muscles; locate the artery by feeling for its pulsations, isolate it, and pass the ligature.

Results.—These are uniformly good.

Temporal Artery.—This artery is the smaller of the terminal branches of the external carotid artery. It arises in the parotid gland opposite the neck of the superior maxilla; and then runs upward to the scalp, dividing into anterior and posterior branches.

Operation.—The artery is located by making a vertical incision, one inch in length, between the tragus of the ear and the condyle of the lower jaw.

Results.—Uniformly favorable.

Internal Maxillary Artery.—This is the larger of the terminal branches of the external carotid. If ligation of the internal maxillary is indicated, it is safer and better to ligate the external carotid. The middle meningeal branch, in cases of intracranial hemorrhage, is tied within the cranium.

Middle Meningeal Branch of the Internal Maxillary Artery.—This artery arises beneath the external pterygoid muscle, between the internal lateral ligament and the neck of the inferior maxillary bone, and ascends between the two heads of the auriculo-temporal nerve to the foramen spinosum. It is crossed by the chorda tympani nerve. It passes through the foramen spinosum into the cranium and divides into anterior and posterior branches, the anterior branch running in a groove or canal in the anterior inferior angle of the parietal bone. Externally, the bifurcation is located 3.8 cm. ($1\frac{1}{2}$ in.) behind the external angular process of the frontal bone, and from 3.8 to 4.5 cm. ($1\frac{1}{2}$ in. to $1\frac{3}{4}$ in.) above the zygoma. This close relationship of the artery to the parietal bone explains the frequent injury of the artery in fractures of the skull at that situation, especially those caused by severe blows upon the head. Its course is upward and a little backward to the sagittal suture. It lies about three-fourths of an inch posterior to the coronal suture. It is located in this situation by measuring one inch posterior to the external angular process of the frontal bone and one and one-half to one and three-fourths inches above the zygoma. The posterior branch runs in a shallow groove along the inner surface of the squamous portion of the temporal bone and passes backward and upward. In the majority of cases it runs somewhat parallel to the squamo-parietal suture. At the beginning it is within three-fourths of an inch of the suture, usually within

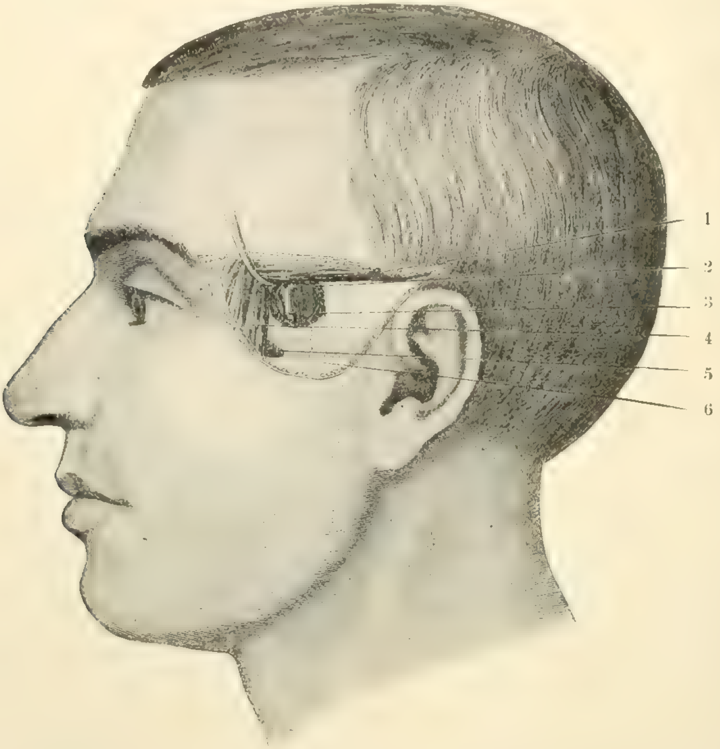


Fig. 275.—Ligature of the Middle Meningeal Artery. (After Kocher.) 1, Small cut in the temporal muscle, to diminish tension; 2, posterior branch of the middle meningeal artery, 3; 4, temporal muscle, pulled to one side to give access to the opening in the skull; 5, crista infratemporalis; 6, upper margin of the zygoma.

one-half inch of it, and it gradually approaches the suture to cross it about three-fourths of an inch from the posterior end of the vessel. (Fig. 275.)

Sites for Ligation.—The common trunk and its anterior and posterior branches.

Ligation of the Common Trunk.—*Kocher's Operation.* (Fig. 275.)—A curved oblique incision is made in such a manner that its centre shall correspond to the site of the trephine opening, which should fall over the trunk of the artery before it bifurcates. The incision begins at the external angular process of the frontal bone, passes obliquely backward and downward to the posterior end of the zygoma, and from this point upward and backward above the ear. The incision is carried down through the periosteum of the bone, care being taken to avoid the branches of the facial nerve and the auriculo-temporal nerve. The temporal muscle is detached subperiosteally and brought forward, exposing the squamous, parietal, and sphenoid bones. The detached parts should be retracted upward and forward, and then, with a trephine 3.8 cm. (one inch and a half) in diameter, a disc of bone should be removed at the point which has already been mentioned. The removal of the disc exposes the artery. The needle is passed around the artery and care is taken not to wound the brain. The disc of bone may be replaced or not as the operator deems fit. The periosteum and its overlying tissues are returned to their normal positions and sutured. The osteoplastic flap operation of Hartley and Krause may be used to expose this artery in special instances.

Ligation of the Anterior Branch.—A horseshoe-shaped incision, with its centre 3.8 cm. (one inch and a half) posterior to the external angular process of the frontal bone, and 3.8 to 4.5 cm. (one and one-half to one and three-fourths inches) distant from the zygoma, is made above the latter bone. The front part of the horseshoe should be just behind the external angular process, and the rear part should correspond to a line that runs vertically upward from the external auditory meatus. The incision is carried through the periosteum, and the flap, comprising the periosteum, is turned upward. The bone is trephined as in the previous operation, and the remaining steps are as previously described.

Ligation of the Posterior Branch.—The external incision should be horseshoe-shaped and its centre should be located just below the parietal eminence. The centre of the trephine opening should be at a point represented by the intersection of a line drawn horizontally on a level with the roof of the orbit, and one drawn vertically from directly behind the mastoid process. The limbs of the horseshoe-shaped incision should be from two to two and three-fourths inches apart. The steps in the operation are the same as those for the ligation cf the anterior branch.

General Considerations.

The middle meningeal artery and its branches are most frequently injured in fractures of the middle fossa of the skull, and this fact plays an important part in the ligature of the vessel. Hemorrhage from these vessels as a result of such injuries are epidural and, with torn dura, may be subdural. The former is in most cases readily treated, and the results are good under favorable conditions. If hemorrhage, as a result of injuries and surgical trauma, be progressive, it will be indicated by the following conditions: Progressive hemiplegia; a pulsating epidural clot; free escape of fluid blood into the soft parts; bleeding in fissured fractures of the skull; the presence of fluid blood in the epidural cavity after the removal of the clot; and the finding of the bleeding point itself. The hemorrhage should be stopped as promptly as is possible. When the bleeding point cannot be located and exposed, the hemorrhage is best arrested by ligature of the external carotid and by the application of cold to the head. When the point of hemorrhage can be suitably exposed, the vessel should be ligated above and below, and, when this is not possible, it may be accomplished by plugging the bleeding points with catgut or kangaroo tendon, or by compression against the internal table by the use of forceps, one blade being within the cavity and one blade without. When compression symptoms result from hemorrhage and are not complicated by a fracture, Kroenlein's method of exposure should be utilized. (For further details consult the article on Surgical Affections and Wounds of the Head, in Vol. V.)

It should also be remembered that this artery and its branches are apt to vary considerably in size and in the course which they pursue, and the operator should examine the surgical anatomy of the part before attempting operative interference.

Internal Carotid Artery.—This artery was first ligated by Keith, of Aberdeen, Scotland, in 1851. In 1869 Dr. Lee, of Kingston, Tenn., successfully ligated the artery in a case of stab wound. Simultaneous ligature of the internal carotid results in about fifteen per cent of deaths, which are due to cerebral complications. Ligature of this artery, with simultaneous ligature of the common or external carotid artery, has been performed in fifteen cases.

Surgical Anatomy.—The internal carotid is the larger of the branches of the common carotid artery. It arises opposite the level of the upper border of the thyroid cartilage. At first, it lies comparatively superficial and slightly external to the external carotid artery, then sinks more deeply into the neck, passes posteriorly to the external carotid, and ascends in front of the transverse processes of the upper cervical vertebræ, to enter the carotid canal.

Operation.—An incision is made along the anterior border of the sternomastoid muscle. The centre of the incision is slightly above the thyroid car-

EXPLANATION OF PLATE XXIX.

Exposure of Arteries for Purposes of Ligation.

Figure 1.

Common Carotid and Subclavian Arteries. (After Zuckerkandl.)

c, Common carotid artery; *F. c.*, deep layer of the cervical fascia divided; *j*, pneumogastric nerve; *k*, sternocleidomastoid muscle.

Lower dissection exposes the subclavian artery under the clavicle. *a*, Subclavian artery; *d*, deltoid muscle; *p*, pectoralis major muscle; *r*, brachial plexus; subclavian vein.

Figure 2.

Dissection of the Axilla. (After Roser.)

3, Subscapularis artery and vein; 8, median nerve; 9, ulnar nerve; 10, axillary vein, behind which passes the ulnar nerve.

Figure 3.

Posterior Tibial Artery behind the Internal Malleolus. (After Zuckerkandl.)

f, Beneath the divided fascia is to be seen the curving artery, accompanied by two veins.

Figure 4.

Anterior Tibial Artery. (After Zuckerkandl.)

E. h., Extensor proprius hallucis; *P. p.*, deep perineal nerve, and behind it the anterior tibial artery, surrounded by veins; *I. a.*, divided fascia.

Figure 5.

Posterior Tibial Artery. (After Zuckerkandl.)

N. t. p., Posterior tibial nerve; *A. t. p.*, posterior tibial artery; *s*, soleus muscle.

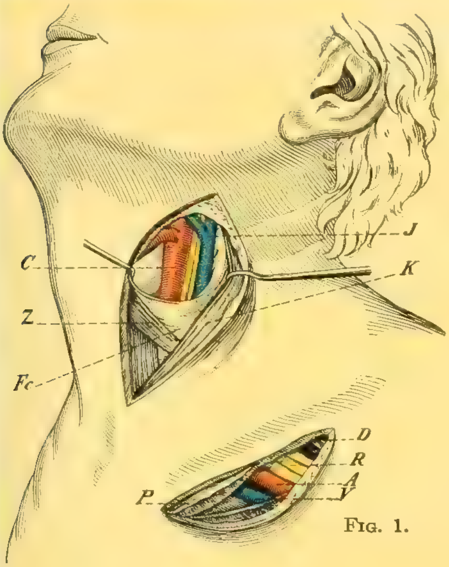


FIG. 1.

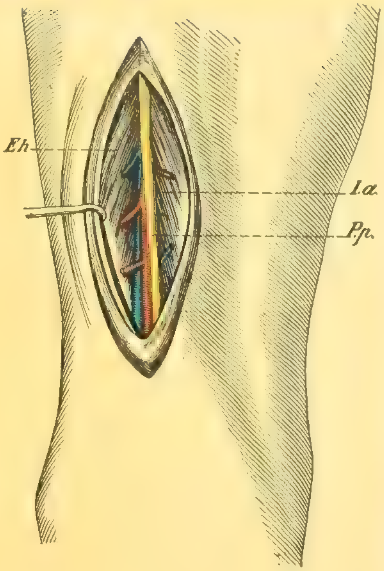


FIG. 4.

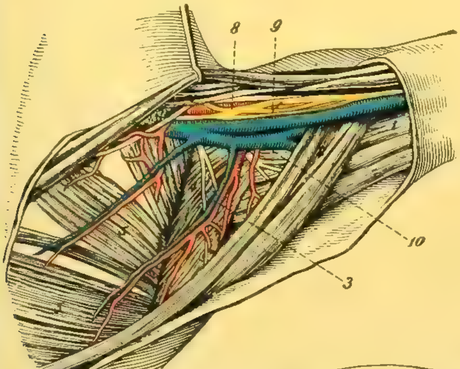


FIG. 2.

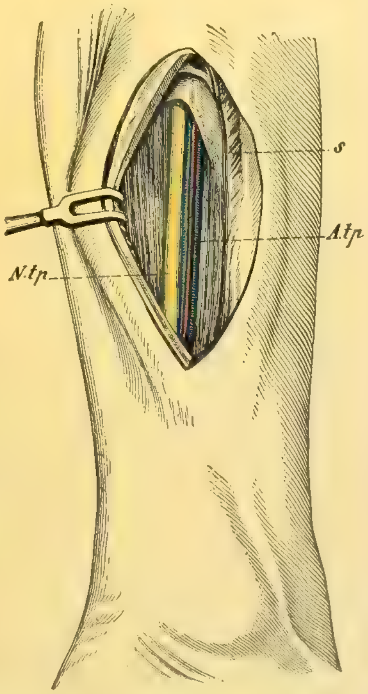


FIG. 5.

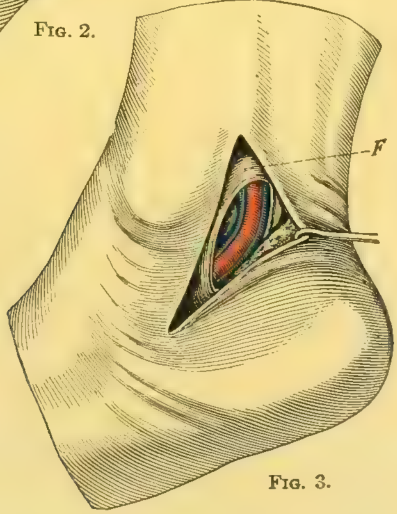


FIG. 3.

DISSECTIONS EXPOSING VARIOUS ARTERIES FOR LIGATION.

(Arteries in red, veins in blue, and nerves in yellow.)

tilage. Further steps in this operation are the same as those for ligating the external carotid below the digastric muscle. (See page 485.)

Subclavian Artery.—*First Portion.*—The first portion of the left subclavian was first ligated by Dr. J. Kearney Rogers, of New York, in 1845. The patient died fifteen days afterward from hemorrhage. Halsted, of Baltimore, in 1898, successfully ligated it in extirpating a tumor. Schumpert has also successfully ligated it for the cure of an aneurism. The first portion of the right side has been ligated twenty-two times. Nineteen of these cases ended fatally, eight of them as the result of hemorrhage. *Second Portion.*—Chilton, of St. Thomas's Hospital, cured an aneurism of the third portion of the subclavian artery by ligating it at the inner border of the scalenus anticus muscle. The following day he ligated the axillary artery. Dr. B. Farquhar Curtis, of New York, reports a case of aneurism cured by ligating the vessel with two strands of catgut, drawn only sufficiently taut to occlude the lumen of the vessel without dividing its inner coat. *Third Portion.*—Of sixteen cases reported, ten were fatal. Nine cases were operated on for aneurisms, with five deaths; seven cases for hemorrhage, with four deaths. These operations were performed, however, before the aseptic period. The three cases ligated for hemorrhage since the aseptic period all ended in recovery. Ligature of the third portion was first attempted in 1809 by Sir Astley Cooper, but he was unable to finish the operation. In the spring of the same year Ramsden ligated the artery, but the case ended fatally. The first successful ligature was accomplished by Wright Post, of New York, in 1817.

Surgical Anatomy.—The subclavian arises from the innominate artery on the right side, and from the arch of the aorta on the left side. The right is about an inch shorter than the left; the left is about 10 cm. (four inches) in length. The vessels on both sides arch over the pleura at the root of the neck to the lower border of the first rib and there become the axillary arteries. The centre of the artery lies between the scalenus anticus and the medius muscles, and is thereby divided into three parts, the first and third portions of which lie respectively internal and external to the scalenus anticus muscle and are of much importance surgically. The subclavian vein lies anteriorly and inferiorly to the artery and in front of the scalenus anticus muscle. (Plate XXVIII, Fig. 1; Plate XXIX, Fig. 1.)

Guides.—The muscular guides are: superficially, the posterior border of the sternomastoid; and, deeply, the scalenus anticus and the tuberosity of the first rib. The linear guide is a curved line with its convexity upward, beginning at the sternoclavicular articulation and ending at the middle of the inferior border of the clavicle.

Operations.—Ligaturing of the first and second portions is extremely dangerous; especially so is ligaturing of the left subclavian artery. The artery in these portions is deep-seated and difficult to reach. It may be exposed either by Mott's method or by Curtis' modification of Milton's method of exposing the anterior mediastinum, as in the ligature of the innominate artery.

Ligation of the First Portion of the Right Subclavian.—The artery is exposed as in Mott's operation for ligation of the innominate. (See page 477.) The subclavian artery is cleared and identified, care being taken not to injure the recurrent laryngeal and the phrenic nerves or the vertebral artery. The pleura is pushed downward and outward by the tip of the finger, and the needle is passed from the pleura below upward. The vertebral artery also should be ligated through the same opening.

Ligation of the First Portion of the Left Subclavian. (Plate XXVIII, Fig. 1.) —The steps in this operation are the same as those taken for ligating the right subclavian as far as the exposure of the common carotid. In this operation the common carotid artery and the pneumogastric nerve are drawn inward, the internal jugular and the left innominate veins are drawn outward and downward. Care should be taken to guard the thoracic duct, which arches from the seventh cervical vertebra over the subclavian artery, in front of the scalenus anticus muscle, to empty into the left subclavian vein at the junction of the vein with the internal jugular. The parts should be relaxed by pulling the head forward. The common carotid is followed downward until the subclavian is found running outward and posteriorly to the carotid. The artery is ligated under the same precautions as those described under Ligation of the Corresponding Portion of the Right Subclavian.

Ligation of the Second Portion of the Subclavian.—An incision is made from the posterior border of the sternomastoid extending three inches along and over the clavicle to the anterior border of the trapezius. Incise skin, fascia, platysma, and the small veins and nerves as encountered. Expose and, when necessary, divide the clavicular attachments of the sternomastoid and the trapezius; then divide the deep cervical fascia, retracting or dividing between two ligatures the external jugular vein and its branches. If the transversalis colli or the superscapular arteries come into view they should be carefully guarded for anastomotic circulation. Retract upward the posterior belly of the omohyoid, and, with the outer margin of the scalenus anticus as a guide, the artery may be located by following the muscles to the tubercle on the upper border of the first rib. The vein will be found in front of the artery and below it. The scalenus anticus should be retracted inward, care being taken to avoid the phrenic nerve, which crosses obliquely the lower anterior surface of the scalenus anticus.

Ligation of the Third Portion of the Subclavian. (Plate XXIX, Fig. 1.)—The steps in this operation are practically the same as those described under ligature of the Second Portion. When the artery has been located at the tubercle of the first rib it is traced outward. The sheath of the artery is opened and the needle passed between it and the brachial plexus, the subclavian vein and the pleura being carefully avoided.

General Considerations.—The right or the left subclavian may, in some instances, pass through the scalenus anticus muscle or it may pass in front of it, with the vein behind it. The right at times takes its origin from the arch of the aorta, in which case it will be more deeply situated. In a few cases the artery courses along a cervical rib and may even be found an inch or two above the clavicle or on a line with it. If the sternomastoid has an unusual breadth of attachment the incision might inadvertently be made too far back. The tubercle of the first rib may be diminutive, in which case the muscular insertion into the rib must be used as a guide. The inner cord of the brachial plexus has at times been mistaken for the vessel.

Vertebral Artery.—Out of forty-four cases operated upon, three were fatal—one from hemorrhage, one from embolism, one from septic pleurisy. Twenty per cent of all cases operated on for epilepsy improve, but the general results do not warrant an operation. Dr. Alexander, who did much of this work, has long ago ceased to advocate its performance for the relief of epilepsy. The artery was first ligated by Smyth, of New Orleans, in connection with ligation of the innominate.

Surgical Anatomy.—It is generally the first and largest branch of the subclavian artery. It arises from the first part of this artery near the inner border of the scalenus anticus muscle, and passes upward, backward, and outward to enter the foramen in the transverse process of the sixth cervical vertebra. It then ascends through the foramina of the transverse processes of all the vertebræ, and, emerging from the foramina in the transverse process of the atlas, it runs in a groove on the posterior arch of the atlas, lying in the suboccipital triangle, and passes into the cranium through the foramen magnum to unite with its fellow on the opposite side, there to form the basilar artery.

Linear and Bony Guides.—The linear guide is a "line drawn from the posterior part of the mastoid process to the junction of the inner fourth of the clavicle with the outer three-fourths of the same. . . . Should difficulty be experienced in finding the artery, a finger must be inserted to the bottom of the wound, and search made with it for the carotid tubercle of Chassaignac, at the extremity of the transverse process of the sixth cervical vertebra, below which the pulsations of the artery may be felt." (Lidell, in Ashhurst's "International Encyclopædia of Surgery," Vol. II., pp. 748, 749.)

Operations.—The vertebral artery is usually ligated in its cervical portion, and occasionally in the occipital portion. The operations are difficult on account of the depth of the vessel, the proximity of important structures, and the difficulty of differentiating it from the inferior thyroid and the ascending cervical arteries.

Chassaignac's Operation.—The incision, three inches in length, is made along the posterior margin of the sternomastoid muscle, almost down to the clavicle; the external jugular is divided and tied between two ligatures, or else is drawn to one side. The muscles, nerves, and veins as encountered are drawn to the inner side; the deep fascia about one inch below the carotid tubercle is opened, and the space between the scalenus anticus and the longus colli muscles is enlarged by blunt dissection. Care should be taken to avoid the ascending cervical artery. When the artery is exposed the ligature is passed with great care so as not to include any of the fibres of the sympathetic nerve.

Kocher's and Fray's Method.—The incision is made along the anterior border of the sternomastoid muscle to its sternal attachment. The platysma and fascia are divided, the sternomastoid muscle and the great vessels are pulled outward, and the sternohyoid muscle is retracted inward. The inferior thyroid artery is located and the prevertebral fascia is divided above so as to expose the vertebral artery which courses vertically, disappearing at the lower margin of the sixth vertebra. In the actual ligation the same care of the wound should be exercised as has been previously noted.

Mikulicz, in cases in which it is difficult to find the vessel because of existing pathological conditions, recommends an incision along the posterior border of the sternomastoid from the level of the thyroid downward. The sternomastoid is divided 3 cm. ($1\frac{1}{5}$ in.) above its clavicular attachment, thus exposing the artery at its origin. After the vessel is ligated the severed muscle should be sutured with catgut.

Helferich's Method.—In this method the effort is made to avoid confounding the artery with neighboring vessels, the artery being reached through the transverse process of the sixth cervical vertebra. An incision is made along the anterior or posterior margin of the sternomastoid muscle, and the muscle is drawn inward or outward as indicated. The carotid tubercle is sought for in the upper part of the wound, and the periosteum is stripped off the transverse process of the sixth cervical vertebra. The outer portion of the process is removed with bone forceps, thus exposing the artery and the vein in the canal. The large vessels and nerves of the neck in this operation do not come into view. The inferior thyroid artery is located below the process, and the phrenic nerve is on the outer side.

Results.—No bad results follow this operation, as a rule. A hemiplegia may appear, but it usually disappears in a few months. Frequently there results a contraction of the pupil on the same side as the ligature, because of injury to fibres of the sympathetic nerve which run parallel to the artery. Barachz reports ligation of both vessels, followed by a temporary hemiplegia. An interval of two weeks occurred between the operations. Barachz and Alexander report forty-one cases of single and double ligature for epilepsy without any bad results.

Inferior Thyroid Artery.—This is the largest branch of the thyroid axis.

It takes an upward and outward course to the posterior surface of the thyroid gland, and passes in front of the vertebral artery, recurrent laryngeal nerve, and longus colli muscle. Anterior to the artery are the great vessels and nerves of the neck.

Operation.—An incision about three inches in length is made along the anterior border of the sternomastoid muscle, with its centre opposite the cricoid cartilage. The skin, superficial fascia, and platysma muscles are divided; the deep fascia is divided, and the sternomastoid and the great vessels of the neck in their common sheath are retracted outward; and the larynx and the thyroid gland are retracted inward. The inferior thyroid artery is recognized by its horizontal course one-half inch below the carotid tubercle, and the part of the vessel beyond its ascending cervical branch is sought. The sympathetic nerve crosses the artery at right angles, and is pulled outward. The ligature is passed from below upward, care being taken to avoid the nerves and the inferior thyroid veins.

Transversalis Colli and the Suprascapular Branches of the Thyroid Axis and the Subclavian Artery.—These are but rarely ligated, and then usually as a result of wounds, in which case they are cut down upon and tied at the points where they are wounded.

Internal Mammary Artery.—This artery arises from the lower part of the subclavian artery near the inner margin of the scalenus anticus muscle, passing downward, forward, and inward behind the clavicle to enter the thorax behind the cartilage and the first rib. It then passes downward and parallel to the external margin of the sternum, being separated from it by an interval of 1.3 cm. (one-half inch). At the interspace between the sixth and seventh costal cartilages it divides into the superior epigastric and the musculophrenic branches.

Surgical Anatomy.—In the neck the artery is covered by the sternomastoid muscle, subclavian and internal jugular veins, and the phrenic nerve. Posterior to it are the pleura and the innominate vein. In the chest it is covered by the cartilages of the first to the sixth ribs, by the pectoralis major, and by the internal intercostal muscles. Posterior to it, above, is the pleura, and below it is the triangularis sterni muscle.

Operation.—The artery is most readily reached through the second intercostal space. The incision is made downward and inward, through all the soft tissues, to the anterior intercostal membrane, which is divided; the deep fascia of the chest is also divided, exposing the artery with its vein to its inner side. The needle is passed between the vein and the artery, care being taken not to wound the pleura.

The vessel can be ligated in any of the five upper intercostal spaces. The course of the vessel is indicated by drawing a line one-half inch external to the outer border of the sternum and parallel to it. The vessel lies midway between the borders of the costal cartilages.

General Considerations.—The internal mammary artery bleeds vigorously. The bleeding from its branches seems proportionately vigorous. Schwartz, in his Koenigsberg dissertation, mentioned 52 cases of injury of the internal mammary artery which had been reported during the past century. Seven of these injuries occurred during operations. Of the remaining 45 cases 9 terminated fatally, by reason of acute hemorrhage. Of the 36 patients who survived there were 24 in whom the wound became infected, and of this number 18 died. Of the 12 patients in whom infection did not occur, 4 died. Secondary hemorrhage occurred in 21 cases. Of the 9 patients who died of acute hemorrhage there were 4 in whom the hemorrhage occurred from the artery itself. In the remaining 5 fatal cases the hemorrhage took place from the lungs, heart, or other neighboring structures.

Axillary Artery.—This artery was first successfully ligated by Dr. Chamberlain, of Jamaica, W. I., in 1815. His operation was for the cure of a traumatic aneurism.

Surgical Anatomy. (Plate XXIX, Fig. 2; Fig. 276.)—The axillary artery is a continuation of the subclavian, extending from the lower border of the first rib to the lower border of the tendon of the teres major muscle, where it becomes the brachial artery. Its length is about 2 cm. (one inch and one-quarter), and it is divided into three parts by the pectoralis minor muscle.

Linear Guide.—A line drawn from the middle of the clavicle to the middle of the bend of the elbow, with the arm placed at a right angle to the trunk.

First Portion.—Anteriorly it is in close relation to the clavicular portion of the pectoralis muscles, the costocoracoid membrane, the external anterior thoracic nerve, and the acromiothoracic and cephalic veins. Posteriorly lie the first intercostal interspace, the first intercostal muscle, the second and a portion of the third digitations of the serratus magnus muscle, and the posterior thoracic and internal thoracic nerves. Externally lies the brachial plexus. Internally lie the axillary vein, which also overlaps the artery, and the anterior internal thoracic nerve.

Operation.—Divide in the linear guide the skin, platysma, supraclavicular nerves and fascia. Divide the clavicular origin of the pectoralis major muscle, and carefully guard the acromiothoracic artery on account of the collateral circulation. Near the coracoid process divide vertically the costocoracoid membrane, through which passes the cephalic vein to empty into the axillary vein; displace the membrane upward and outward; expose the sheath and clear the artery, bringing the arm nearer to the body so that the axillary vein will be transferred from over the artery to its inner side. The needle is passed between the adjacent nerve cords and the artery.

Second Portion.—This portion of the artery lies behind the pectoralis minor muscle. Anteriorly, it is covered by the pectoralis major and minor muscles; posteriorly, lie the subscapularis muscle and the posterior cord of the brachial plexus; externally, lies the outer cord of the brachial plexus; internally, lie the axillary vein, the inner cord of the brachial plexus, and the internal anterior thoracic nerve.

Operation.—No special description for ligature at this situation is called for, as the artery may be reached by extending the incisions described under Ligature of the First Portion and Ligature of the Third Portion. If ligature at this immediate position of the artery is indicated, the vessel may be reached by dividing the tissues down to and through the space between the contiguous borders of the deltoid and the pectoral muscles. The pectoralis minor is exposed and drawn downward and the artery is isolated. The main vessel and its collateral branches are ligated in the usual manner.

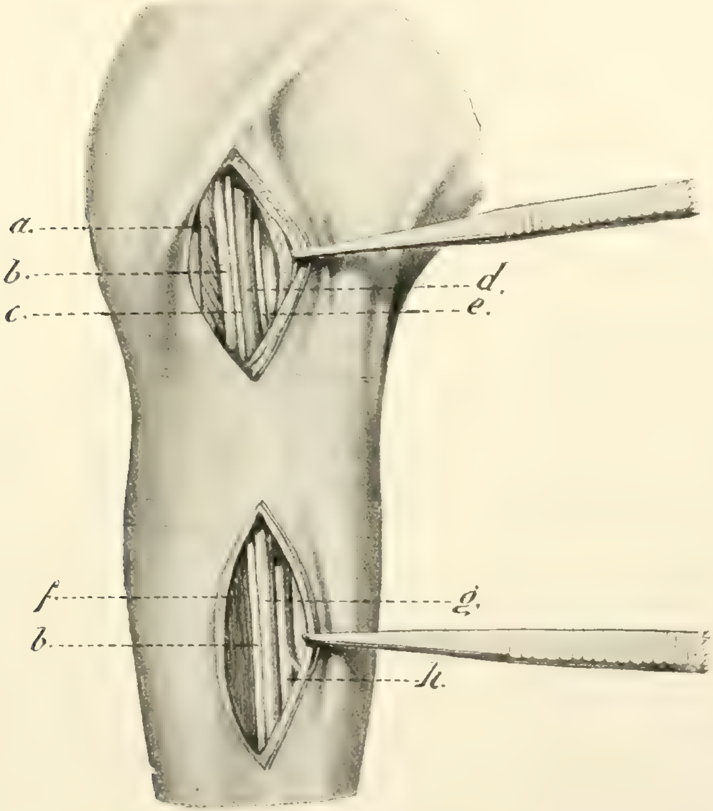


FIG. 276.—Exposure of Axillary and Brachial Arteries. (After Zuckerkandl.) *a*, Coracobrachialis muscle; *b*, median nerve; *c*, greater internal cutaneous nerve; *d*, axillary artery; *e*, lesser internal cutaneous nerve; *f*, biceps muscle; *g*, brachial artery; *h*, brachial vein.

Third Portion.—This portion extends from the lower border of the pectoralis minor to the lower border of the tendon of the teres major muscle. In front of the artery are the skin, the superficial fascia, the pectoralis major muscle, the deep fascia of the arm, the internal root of the median nerve, and the external brachial vein. Behind it are the musculospiral and circumflex nerves and the subscapularis, latissimus dorsi, and teres major muscles. Internally lie the internal root of the median nerve, the ulnar, internal cutaneous, and lesser internal cutaneous nerves, and the axillary vein.

Operation. (Fig. 276.)—An incision about three inches in length is made along the posterior border of the coracobrachialis muscle, from the juncture of the anterior and middle thirds of the axilla along the linear guide. Expose the inner border of the muscle and draw it and the musculocutaneous and median nerves upward, while the ulnar and internal cutaneous nerves are drawn inward. The axillary vein is slightly below and slightly in front of the artery. The needle should be passed between the vein and the artery and as far away from a large branch of the artery as is possible.

General Considerations.—Not infrequently the radial artery, sometimes the ulnar and possibly the interosseous, arise from the axillary. Traumatic aneurism of this vessel is of comparatively frequent occurrence from violent movements and direct injuries in the efforts at reduction of a dislocated shoulder joint.

Brachial Artery.—Ligature of this artery is of historic interest on account of the operation which Anel brought before the profession for the cure of traumatic aneurisms of the elbow. Before the aseptic period almost one-third of these operations resulted fatally, but in these days the artery is ligated with comparative safety.

Surgical Anatomy.—The brachial artery is a continuation of the axillary artery and extends along the anterior and inner aspect of the arm, from the lower border of the teres major muscle to about 1.3 cm. (one-half inch) below the bend of the elbow. It divides into the radial and ulnar arteries. The vessel is superficial throughout its course. Its relations are as follows: Anteriorly, skin, superficial and deep fascias. The median nerve crosses it in the middle; the median basilic vein and bicipital fascia cross it at the elbow. Posteriorly, it lies from above downward upon the long head of the triceps, the musculospiral nerve and superior profunda artery intervening; then upon the inner head of the triceps, and finally upon the insertion of the coracobrachialis and brachialis anticus muscles. Externally, it is in relation with the commencement of the median nerve and the coracobrachialis and biceps muscles. Internally, the upper half is in relation with the internal cutaneous and ulnar nerves, the lower half with the median nerve. (Fig. 276; Plate XXIX, Fig. 1.)

Linear Guide.—A line extending from the junction of the middle and anterior thirds of the axilla to midway between the apices of the bony condyles of the humerus.

Operation. (Plate XXIX, Fig. 1.)—The arm being abducted and semiflexed, an incision about 2.3 in. in length is made along the internal bicipital groove. The internal edge of the biceps is exposed and retracted outward, when the artery will be found under its inner border. The median nerve usually crosses the artery at its middle; the internal cutaneous nerve lies on its inner side. The venæ comites and the basilic vein are separated from the artery. The needle is passed around the artery between itself and the nerve. Do not let the arm rest in such a posture as to facilitate the error of mistaking the triceps for the biceps, the ulnar nerve for the median, or a large profunda artery for a small brachial. The possibilities of anomalies should be borne in mind, especially that of an unusually high termination of the brachial. In this case the ligation of one division only would defeat the purpose of the operation.

Ligation at the Elbow.—The brachial artery lies in the interior cubical sulcus and, covered by the aponeurosis of the biceps muscle, is embedded in the depression between the pronator radii teres and the biceps muscles. The artery in this position is accompanied by two symmetrically placed veins; the median nerve does not occupy the same intimate relation to the artery as it does in the arm, being displaced to the ulnar side of the vessel. Separated from the artery by the bicipital fascia, and situated subcutaneously, is the plexus of veins (median basilic and median cephalic), which are continuous, in the flexure of the elbow, with the veins of the forearm. The simplicity of the relations existing in the arm, in consequence of the prominences formed by the biceps and the triceps and the presence of the internal and external bicipital sulci, is replaced at the flexure of the elbow joint by somewhat complex conditions resulting from the presence of two large groups of forearm muscles arising from the arm.

Operation.—The forearm is extended at the elbow joint and is held in a position of maximum supination. Information as to the course and situation of the internal bicipital sulcus is sought through palpation. An incision about two inches in length, with its centre in the fold of the elbow, is made along the internal border of the biceps tendon.

General Considerations.—In females, owing to the unusual length of the internal condyle, the primary incision should be made midway between the apices of the condyles. The chances of missing the artery are thus diminished. Unusual muscular development may make the finding of the artery difficult, in which case the pulsation of the vessel will indicate its location. The median nerve may pass behind instead of in front of the vessel, and for this reason might be included in the ligature with the artery. The brachial may bifurcate unusually high up, or the vessels of the forearm may arise from the axillary artery, in which circumstances the number of vessels encountered in the arm will be confusing. This artery may accompany the ulnar nerve behind the inner condyle. Reliance should be placed on the size of the vessel and upon the influence which pressure effects upon the circulation distal to the site of the proposed ligation.

Radial Artery.—The radial artery is a continuation of the brachial and is the smaller of its terminal branches. It begins just below the crease in the elbow, passing down the forearm on its radial side to the wrist, where it winds around the outer surface of the carpus, beneath the external tendons of the thumb, to the upper end of the space between the first and second metacarpal bones. It then passes forward between the two heads of the first dorsal interosseous muscle into the palm of the hand, and finally crosses the metacarpal bones to the ulnar border of the hand, anastomosing with the deep branch of the ulnar artery to form the deep palmar arch. (Plate XXVIII, Fig. 3.)

Linear Guide.—It is a line drawn from one-half inch below the crease of the elbow joint, midway between the two condyles, to the inner side of the styloid process of the radius.

Operations.—The artery is ligated in its upper, middle, and lower thirds.

Ligature in the Upper Third.—An incision two or three inches in length is made along the inner border of the supinator longus muscle, the centre of the incision corresponding to the junction of the upper and middle thirds of the artery. Divide skin, superficial and deep fascias; widen the space between the supinator longus and the pronator radii teres muscles. The artery will be found under the edge of the supinator longus.

Ligature in the Middle Third.—The incision, two and a half inches in length, is made along the linear guide, with its centre at the centre of the forearm. Divide the skin, the superficial and the deep fascias, retract the supinator longus outward, and the artery will be found lying upon the flexor sublimis digitorum and the flexor longus pollicis. The radial nerve is to the radial side of the artery and may not come into view.

Ligature in the Lower Third. (Plate XXVIII, Fig. 3.)—The incision, 2.5 to 5 cm. (one to two inches) in length, is made along the linear guide, between the supinator longus and the flexor carpi radialis muscles. Divide the skin and superficial fascia; displace to one side the radial vein, or any branch of it, and the superficialis volæ artery if it comes into view. Then divide the deep fascia and enlarge the space between the tendons, pushing the supinator longus toward the outer side and the flexor carpi radialis toward the inner, and thus exposing the artery and its venæ comites. The anterior branch of the musculocutaneous nerve accompanies the vessels.

Ligature of the Deep and Superficial Palmar Arches. (Fig. 277.)—The superficial and deep palmar arches can well be considered together. Their intimate relations with contiguous nerves, tendons, etc., and with each other, along with the numerous branches given off by each, require care in dissection and tying, especially in the case of the deep arch, because of the close association of their branches with each other, as bearing on the possibility of secondary hemorrhage.

Linear Guides.—The linear guide of the superficial arch extends from the palmar border of the thumb, adducted to a right angle, directly across the palm. The deep arch is located one-half to three-fourths of an inch nearer the wrist joint. In crush injuries of the palm, secondary hemorrhage is of common occurrence.

In the operation for ligaturing the deep palmar arch the patient's hand should be extended. The limb as a whole should be supine. An incision is made a half-inch or so above that for the superficial arch, as indicated above. Divide the skin and the superficial fascia; expose and ligate the superficial palmar arch; divide the muscles of the thenar eminence; and, at the upper end of the wound, divide as little of the annular ligament as possible. Then the flexor tendon of the index finger, its lumbrical muscle, and the muscles of the thumb are retracted from one another, exposing the adductor obliquus pollicis, which is divided. The deep palmar arch will be found beneath it, running trans-

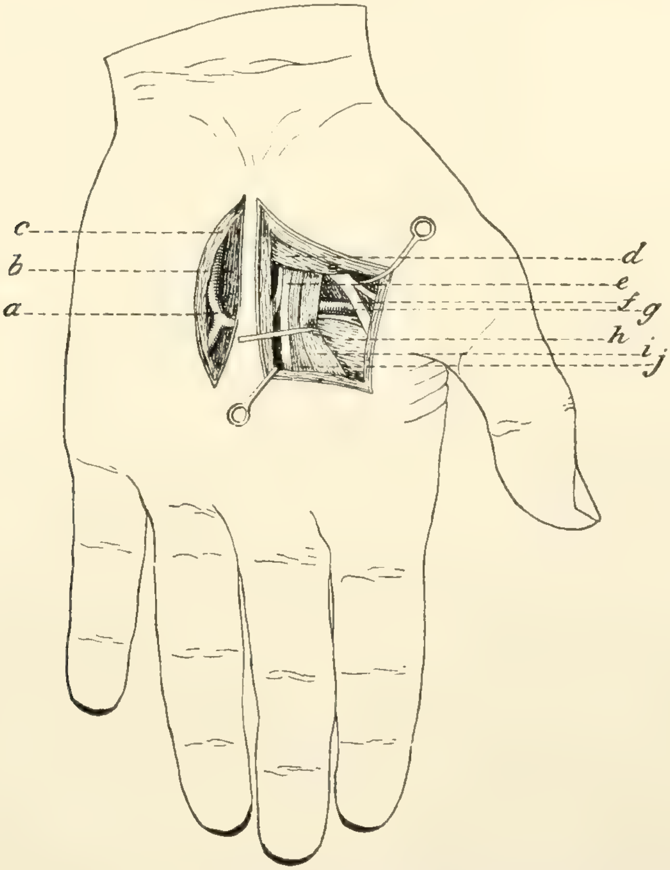


Fig. 277.—Ligatures of the Superficial and Deep Palmar Arteries. (After Kocher.) *a*, Superficial palmar arch; *b*, tendon of the flexor sublimis digitorum to the fourth finger; *d*, opponens pollicis muscle; *e*, median nerve to the middle and the ring fingers; *f*, median nerve to the index finger and to the thumb; *h*, adductor pollicis muscle; *i*, first lumbrical muscle; *j*, tendon of the flexor sublimis digitorum.

versely across the hand. In this deep wound the needle is to be carefully passed so as to avoid nerves and veins.

In ligaturing the superficial palmar arch (Fig. 277) the operation is done as follows: The limb being in a supine posture, the hand extended, and the fingers and wrist steadied, incise the skin along the linear guide. The artery will be found in the underlying fat. The median and ulnar nerves and the flexor tendons will be found underneath the vessel. When unable to locate the arch, ligate the ulnar artery at the pisiform bone.

Ulnar Artery.—This artery is the larger of the terminal branches of the brachial artery. It commences half an inch below the bend of the elbow; its upper end crosses the forearm obliquely with a slight convexity to the ulnar side. The lower half runs along the ulnar border of the forearm to the wrist, where it crosses the annular ligament to the radial side of the pisiform bone and enters the palm, to divide into the superficial and deep palmar branches. These branches enter into the formation of the superficial and deep palmar arches. (Plate XXVIII, Fig. 3.)

LINEAR GUIDE.—This is formed by drawing a line from the internal condyle to the radial side of the pisiform bone.

OPERATIONS.—The artery is ligatured in its upper, middle, and lower thirds. Ligature oi the upper third is only very exceptionally called for.

Ligature of the Middle Third.—Divide skin and superficial fascia, exposing the internal cutaneous nerves and the anterior ulnar vein, which is drawn to one side. The deep fascia is divided a little to the outside of the above incision, as the flexor carpi ulnaris slightly overlaps the flexor sublimis digitorum; these muscles are then well retracted, exposing first the ulnar nerve and, internal to it, the ulnar artery surrounded by its venæ comites. The incision should be about two inches in length.

Ligature of the Lower Third.—An incision two inches in length is made along the linear guide to the radial side of the tendon of the flexor carpi ulnaris, terminating about one inch above the pisiform bone. The muscular belly of the muscle, which extends almost to the wrist, is retracted outward, and the ulnar artery, accompanied by its venæ comites, is exposed. The ulnar nerve is to the ulnar side of the artery, and the needle is passed between it and the nerve.

Intercostal Arteries.—The nine or ten intercostal branches of the thoracic aorta supply, as a rule, the parts from the third to the eleventh intercostal spaces inclusive. The first intercostal space is supplied by the superior intercostal alone; and the second space is supplied either by the superior intercostal alone or by it and the first aortic intercostal. The branch below the twelfth rib is known as the subcostal artery. The vertebral portions of the intercostal arteries arise in pairs from the posterior part of the thoracic aorta and pass around the vertebræ. The arteries divide into dorsal and intercostal branches; the intercostal branches run forward and obliquely upward in the intercostal space and divide, at the lower border of the superior rib near its angle, into upper and lower branches.

Ligation of an Intercostal Artery.—The patient is supine, the trunk turned so as to leave the site of operation readily accessible, and the chest is supported below so as to increase the width of the intercostal spaces. An incision, 5 cm. (two inches) in length, is made parallel to and just below the lower border of the rib, in the groove of which runs the vessel to be operated on. The skin and superficial fascia are divided, and then the overlying muscular tissues of the chest are incised, exposing the intercostal fascia, which is also incised. The external intercostal muscle is divided, the cut edges are drawn upward and downward, and the artery is sought for in the inferior intercostal groove. The intercostal nerve will be below it, and the vein above it. With an aneurismal needle the artery should be drawn into view and divided between two ligatures. The intercostal muscle and fascia are to be sutured with catgut. In some cases it may be necessary partially to excise a rib in order to get at this vessel. In this case the incision is made directly over a rib, and the tissues are divided down to and including the periosteum. With the periosteum elevator the periosteum is freed from the lower half of the anterior surface of the bone, from its inferior groove, and from the lower half of the posterior groove, all subperiosteally. Then a half button of bone is removed with a rongeur forceps, care being taken to insert the lower blade of the rongeur between the bone and its detached periosteum. Finally, the periosteal membrane is incised directly over the artery. (Hartley.)

Abdominal Aorta.—This artery was first ligated by Sir Astley Cooper in 1817. His patient lived forty hours. In 1842 Monteiro, of Rio de Janeiro, ligated this vessel, and his patient lived ten days. In 1856 South operated on a patient who lived forty-three hours; in 1869 Watrous operated on one who survived five hours. In 1899 Keen, of Philadelphia, ligated this vessel, and the patient survived the operation forty-eight days. In 1900 Tillaux ligated the vessel, and the patient survived for thirty-nine days. In 1902 Morris, of New York, ligated the abdominal aorta, and his patient survived fifty-three hours. Out of the fifteen cases reported, eight succumbed a few hours after operation. Keen's case, at autopsy, showed that the aorta had ulcerated at the point where the ligature had been applied, despite the fact that he had used four large silk sutures. The patient died of hemorrhage. Keen concluded from his observations that, although a patient may live after ligation of the aorta, the aorta will eventually be cut through by any ligature that can be applied, because of the strong expansile tug at the point of ligation. Morris, in his case of aneurism, ligated the artery above and below the sac with rubber catheters, which he removed after twenty-five hours. The patient died of peritonitis on the third day after operation. The autopsy showed an apparently satisfactory clot in the aneurism. Although the results of this ligature have been uniformly fatal, the hopes, meagre though they are, which are inspired by the cases enumerated above, prompt the giving of a description of the technique of this operation. Two methods are employed—the transperitoneal and the retroperitoneal operation. The first is the more desirable method.

Transperitoneal Method.—A vertical incision four inches in length, with its centre on a level with the umbilicus, is made slightly to the left of the navel. If the incision be placed so as to invade the rectus, additional reparative security will be attained. Divide all the tissues through to the peritoneal cavity as in any laparotomy. Retract the small intestines and mesentery upward and to the sides; and, with the fingers as a guide, trace the artery upward from its bifurcation. It is detected by its pulsations. The peritoneum covering it, between its inferior and its mesenteric branch, is vertically divided, care being observed not to injure the sympathetic fibres resting on its anterior surface. The ligature is applied below the inferior mesenteric artery. Heavy, flat kangaroo tendon, No. 4 chromicized catgut, or soft silk floss should be the ligature material used. The Ballance-Edmunds knot is available here. The needle is passed between the aorta and the inferior vena cava.

Retroperitoneal Method.—The patient is placed on his right side; the surgeon stands behind the patient and upon the side of the operation. The incision starts 1.3 cm. (one-half inch) above Poupart's ligament and passes upward and outward, parallel to the ligament, to the anterior superior spine; and is carried upward in the cleavage line of the external oblique as far as the case calls for. Additional room may be obtained by making a right-angle continuation of the incision, having it run parallel to the rib. Incise the skin and superficial fascia, exposing and ligating the superficial epigastric and branches of the superficial iliac arteries and their veins, and then expose the aponeurosis of the external oblique muscle. Incise the aponeurosis in its cleavage line, continuing the incision upward and separating the fibres of the muscles and the fibres of the internal oblique and transversalis muscles as far upward toward the eleventh rib as is necessary. The incision of the latter muscles corresponds in direction to the separation of the external oblique. The dorsal nerves, as encountered between the internal oblique and transversalis muscles, are to be carefully preserved. The deep circumflex iliac artery and the lumbar arteries are likely to be found above the crest of the ilium. Divide the transversalis fascia and separate the peritoneum from the iliac fascia, drawing it backward and downward to the psoas muscle, and then upward to the sacral promontory, thus exposing the floor of the iliac fossa. We find first the external iliac artery, then the common iliac, and then the deep epigastric arteries. The external cutaneous, genito-crural, and the anterior crural nerves and the spermatic arteries cross this area. The ureter, opposite the first piece of the sacrum, obliquely crosses either the common iliac or the external iliac artery, having the ilium in front of it on the right and the sigmoid flexure of the colon on the left. As a rule, however, the ureter adheres to the peritoneum and is thus withdrawn from the field of operation. The artery having been reached by following up the common iliac and reflecting back the peritoneum from the iliac fossa, the ligature is placed in the same position as in the transperitoneal method.

Common Iliac Arteries.—The common iliac was first ligated in 1812 by W. Gibson, of Philadelphia. Valentine Mott, of New York, in 1827, ligated the common iliac arteries for a case of aneurism of the internal iliac branch by the extraperitoneal route. His method is followed to-day and is, for some, the operation of choice, many others regarding the transperitoneal through the rectus as the better. Ligature has been successfully applied to this artery many times; nevertheless, the mortality still remains high.

SURGICAL ANATOMY.—The common iliac arises from the bifurcation of the abdominal aorta opposite the lower border of the left side of the fourth lumbar vertebra. This point corresponds to a line passing transversely through the highest points of the iliac crests. The arteries (one for each side) pass outward and downward over the body of the fifth lumbar vertebra to the edge of the pelvis, dividing opposite the border of the sacro-iliac synchondrosis into the external and internal iliac arteries.

Relations of the Right Common Iliac Artery.—Anteriorly: the peritoneum, right ureter, ovary (in females), terminal branches of the superior mesenteric artery, branches communicating between the sympathetic and the hypogastric plexus of nerves. Posteriorly: right common iliac vein, termination of the left common iliac vein, beginning of the inferior vena cava. Externally: inferior vena cava, right common iliac vein, termination of the left common iliac vein, and the hypogastric plexus of nerves.

Relations of the Left Common Iliac Artery.—Anteriorly: peritoneum, small intestines, ureter, ovarian artery (in females), branches communicating between the sympathetic and the hypogastric plexus of nerves, inferior mesenteric artery, sigmoid flexure and superior hemorrhoidal artery. Posteriorly: lower part of the fourth lumbar vertebra, fifth lumbar vertebra, and the left common iliac vein. Externally: psoas muscle. Internally: left common iliac vein, hypogastric plexus, middle sacral artery.

RESULTS.—Out of sixty cases reported, eighteen resulted in recovery. Of this number thirty-four were operated on for aneurism, eighteen for hemorrhage, and eight for malignant disease. The fatalities were: twenty-two for aneurisms, fourteen for hemorrhage, and six for malignant disease. Ninety per cent of these cases, however, were done before the aseptic period.

LINEAR GUIDE.—Two transverse lines are drawn across the abdomen—one between the highest points of the crests of the ilium, the second between the anterior superior iliac spines. Then a third line is drawn midway between the symphysis pubis and the anterior superior iliac spine to within half an inch of the other side of the centre of the first line. That part of the last line which lies between the first two lines indicates the position of the common iliac; and that part of the third line which lies below the second line indicates the position of the external iliac.

Operations.—Retroperitoneal and transverse peritoneal methods.

Retroperitoneal Method.—An oblique incision is made 1.3 cm. (one-half inch) above and parallel to Poupart's ligament. The incision extends to the anterior superior iliac spine and is prolonged upward through the cleavage in the external oblique muscle. By separating the fibres of the external oblique and dividing the fibres of the internal oblique and the transversalis muscles, one may readily continue the opening as far up toward the eleventh rib as may seem necessary. The incision through the fibres of the latter muscles should correspond in direction to the line of separation of the fibres of the external oblique. In the higher portion of the wound the dorsal nerves may be met, and they should be carefully preserved. After the transversalis fascia has been divided and the peritoneum has been separated from the iliac fascia, the former is pulled downward and backward to the psoas muscle, and the floor of the iliac fossa is closed. The conditions met with here are the same as those encountered in the retroperitoneal operation for the ligature of the abdominal aorta. (See page 506.) The artery having been reached and separated from the peritoneum, the needle is passed between it and the iliac vein.

Transperitoneal Method.—The steps for ligature of the left common iliac are practically the same as for ligature of the abdominal aorta; the fibres of the left rectus muscle being included in the incision with the view of gaining greater reparative security. Briefly stated, the right common iliac may be approached through the right rectus, near the linea alba, by an incision (four inches in length) the centre of which corresponds to a line drawn on a level with the crests of the ilium, and the left common iliac through an incision made at the centre of the left rectus and corresponding in other respects to the one just described. Special care should be taken to see that the ureter is properly isolated, so that it shall not be injured before the peritoneum is incised.

General Considerations.—These operations are attended with considerable danger. Care should be observed not to puncture the iliac veins, not to include the ureter in the ligature, and not to injure the peritoneum. The patient should be thoroughly anæsthetized, so as to reduce to a minimum the chances of struggling, vomiting, or coughing which would interfere with the operation. The peritoneum should be handled as little and as gently as is practicable. It should be remembered also that the vessel is at times difficult of location and that its origin and course may be abnormal.

Internal Iliac Artery.—This artery was first ligated by Dr. W. Stevens, of Santa Cruz, in 1812. It is a difficult vessel to ligate because of the relations that the ureter and veins bear to it.

Surgical Anatomy.—The internal iliac artery arises from the bifurcation of the common iliac, and descends into the pelvis as far as to the upper margin of the great sacrosciatic foramen, dividing into anterior and posterior branches. It is about 4 cm. (one inch and one-half) in length.

Relations.—Anteriorly: peritoneum, ureter; posteriorly: external iliac vein, internal iliac vein, psoas muscles, lumbosacral cord, obturator nerve, and the sacrum; externally: psoas muscle; internally: internal iliac vein, peritoneum.

Results.—Out of seventy-four cases reported, twenty-five were fatal. The great majority of fatalities resulted from attempts to cure aneurism and to arrest hemorrhage. By the transperitoneal method the results have been fairly good. Out of five cases operated on for aneurisms, one was fatal. The late Dr. Pryor, of New York, through a median abdominal incision, simultaneously ligated both vessels for malignant disease of the uterus. Out of thirty-four cases one terminated fatally. Meyer, of New York, simultaneously ligated with operative success both vessels for prostatic enlargement. As the technique and control of asepsis are being brought more and more to perfection, the transperitoneal instead of the retroperitoneal becomes the method of choice. The transperitoneal method requires us to prepare the patient in a more thorough manner; it gives us a better view of the field of operation; it permits of the vessels being ligated higher up without modifying the incision; and, as the sac is less disturbed, there is less danger of hemorrhage in operating on an aneurism. The possible dangers of peritonitis and shock are much outweighed by the actual advantages over the old method.

The chief dangers in this operation are from gangrene of the limb, peritonitis, and secondary hemorrhage.

Precautions.—These are the same as those noted in the section devoted to the external iliac. (See page 514.)

Operations.—The internal iliac artery may be operated on either by a retroperitoneal or by a transperitoneal method. These operations are practically the same as those described for the ligation of the common iliac artery. After the common iliac has been exposed, the internal is sought for by following it to its bifurcation. The linear guide is the same as that described under ligature of the common iliac artery (page 507).

Obturator Artery.—This artery arises, as a rule, from the anterior division of the internal iliac, but often from the posterior division. It runs downward and forward from below the brim of the pelvis to the upper end of the obturator foramen, and divides, on its exit from the foramen, into external and internal branches.

Operation.—The patient is supine, with the limb slightly abducted and rotated outward. The artery is ligated at its exit from the thyroid foramen. An incision is made vertically from a point about 2.3 cm. (three-fourths of an inch) internal to the centre of Poupart's ligament, and extends downward. The skin, the superficial fascia, and the fascia lata are divided. The internal saphenous vein is pulled outward. The fascia over the peritoneum is incised just internal to the femoral vein. The muscle is drawn inward, thus separating it from the pubic bone and from the fascia of the obturator externus. The fascia of the obturator externus is then divided so as to expose the muscle to view. The upper border of the muscle is followed to the inferior margin of the obturator foramen—to the groove intended for the vessels and the nerve, where they are to be found lying, the nerve above and the vein below.

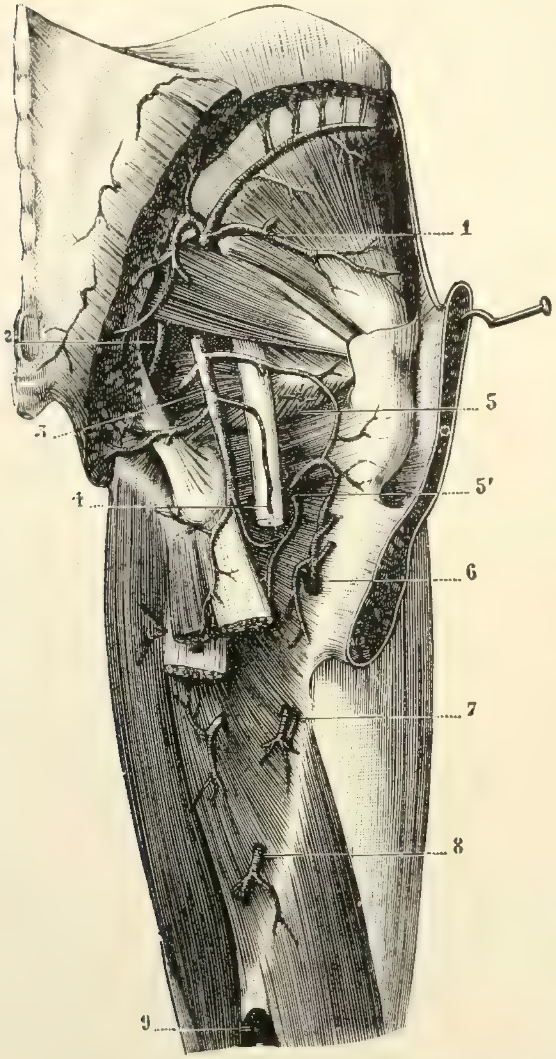


Fig. 278.—Anatomical Relations at the Back of the Thigh and in the Gluteal Region. (After Testut.) 1, Gluteal artery and its branches; 2, internal pudic; 3, sciatic and its branches; 4, artery supplying the sciatic nerve; 5, 5′, terminal branches of the posterior circumflex; 6, 7, and 8, first, second, and third perforating arteries; 9, popliteal artery emerging from the ring formed by the adductors.

Sciatic Artery.—This artery is the larger of the branches of the interior trunk; it passes above the sacral plexus and the pyriformis muscle to the lower part of the great sacrosciatic foramen, where it passes out of the pelvis on to the buttocks, beneath the gluteus maximus muscle, descending half way between the trochanter major and the tuberosity of the ischium. (Fig. 278, 3.)

Operation.—The patient is placed upon the opposite side with the knee flexed and the thigh rotated inward. The linear guide is drawn from the posterior superior iliac spine to the outer border of the tuberosity of the ischium. The incision, about 10 cm. (four inches) in length, should cross the linear guide obliquely in the direction of the fibres of the gluteus maximus muscle. Incise the skin and the fatty tissue, and the separate fibres of the gluteus maximus in their cleavage line; retract the divided margins upward and downward respectively, exposing the lower margin of the pyriformis muscle. The artery will be found emerging from beneath the muscle; it passes over the spine of the ischium and lies posterior and external to the pudic artery.

Internal Pudic Artery. (Fig. 278, 2.)—This artery, which is the smaller of the terminal branches, passes over the pyriformis muscle and the sacral plexus of nerves to the lower border of the great sacrosciatic foramen. Lying anteriorly and to the inner side of the sciatic artery it passes out of the pelvis between the coccygeus and the pyriformis muscles. It crosses over the outer surface of the spine of the ischium, under the gluteus muscle, and re-enters the pelvis through the lesser sciatic notch. It then passes over the obturator internus muscle and runs along the external wall of the ischiorectal fossa, above the lower margin of the tuberosity of the ischium. It is contained in a canal of the obturator fascia. Approaching the lower border of the ischial ramus it runs upward and forward, piercing the posterior layer of the deep peritoneal fascia, running forward along the inner border of the ramus of the pubis, and giving off the artery of the crus penis and the artery of the bulb. Finally, it pierces the anterior layer of the deep perineal fascia as the dorsal artery of the penis.

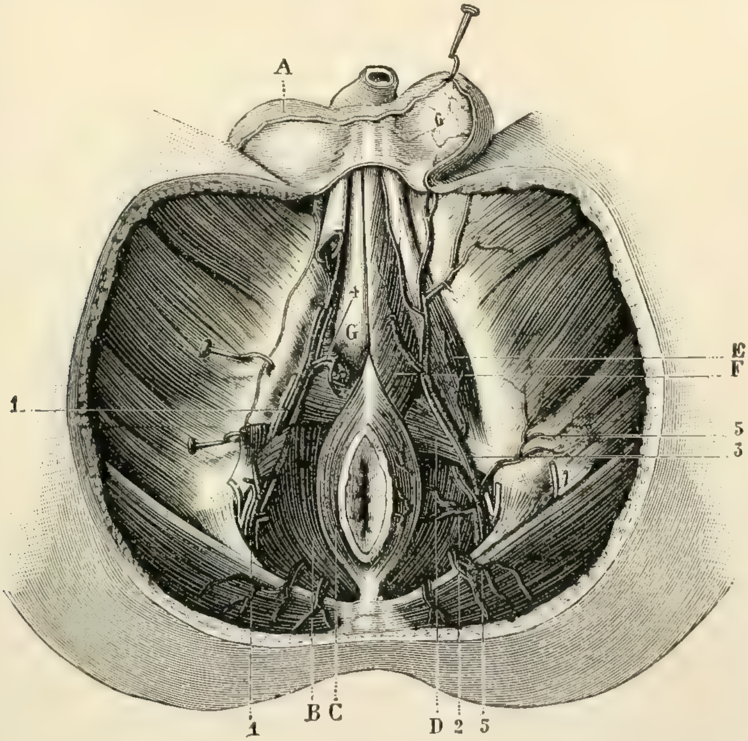


FIG. 279.—Perineal Blood-vessels in the Male. (After Testut.) *A*, Scrotum; *B*, levator ani muscle; *C*, sphincter; *D*, transversus perinæi muscle; *E*, ischio-cavernosus muscle; *F*, bulbo-cavernosus muscle; *G*, bulb of the urethra; 1, internal pudic artery, accompanied by its two veins and by the nerve of the same name; 2, inferior hemorrhoidal artery; 3, superficial perineal artery; 4, deep perineal artery; 5, muscular branches; 6, scrotal branches.

Operation.—The linear guide is the same as that for the sciatic artery.

This artery may be ligatured in either the gluteal or the perineal region.

Operation in the Perineum.—The patient is in the lithotomy position. The pudic lies above and to the inner side of the scrotal and separated from it by the pudic nerve. An incision is begun about 7.5 cm. (three inches) above the inner border of the tuberosity of the ischium, and is continued downward along the inner edge of the ascending ramus of the ischium. The skin and fascia are divided, care being taken to avoid the inferior pudendal nerve, which lies beneath the fascia. The erector penis muscle is disclosed in the male; the transversus perinæi muscle is drawn downward and inward, and, when necessary, is divided. The triangular ligament and the adjacent parietal pelvic fascia are divided, thus exposing the artery. The artery will be found running forward above the pubic nerve from the inner surface of the obturator internus muscle. (Fig. 279, 6.)

Gluteal Artery.—This was first ligated by John Bell, in 1801.

Surgical Anatomy.—The gluteal artery is the largest branch and a continuation of the largest division of the internal iliac artery. It descends backward between the first sacral nerve and the lumbosacral cord, leaving the pelvis through the upper side of the sacrosciatic notch, in the groove formed by the margin of the bone and the pelvic fascia. It divides under the gluteus maximus muscle into its branches. (Fig. 278, 1.)

Operation. (Fig. 280.)—The line of the artery is indicated as follows: with the thigh slightly flexed and rotated inward, a line is drawn from the posterior superior iliac spine to the top of the great trochanter. The junction of the upper and middle thirds of this line indicates where the artery emerges from the sciatic notch, which is the point of selection for the operation. An incision, about 10 cm. (four inches) in length, is made along this line, the centre of which corresponds to the point where the artery emerges from the sciatic notch. Divide skin, superficial fascia, and the gluteus maximus. Incise the muscle along its cleavage line, where a branch of the crural artery will generally be found between the gluteus medius and the pyriformis muscles. Then divide the fascia over the lower border of the gluteus medius, separate the two last-mentioned muscles with retractors, and expose the upper margin of the sciatic notch by running the finger under the lower border of the gluteus medius. The artery, with its accompanying vein, and the superior gluteal nerve emerge from the foramen through the upper portion of the sciatic notch; they lie between the gluteus medius and the pyriformis muscles.

External Iliac Artery.—This artery was first ligated by Abernethy, in 1796. Out of one hundred and seventy cases reported, one hundred and thirty-four ended in recovery. Under aseptic precautions about eighty-five per cent of all patients operated on should recover. The greatest number of operations performed was for aneurisms; hemorrhage followed next, and then tumors.

SURGICAL ANATOMY.—The external iliac artery is the larger of the terminal branches of the common iliac. It arises at the sacro-iliac synchondrosis, descends obliquely outward along the brim of the pelvis from the inner border of the psoas muscle, and then passes, midway between the anterior superior spine of the ilium and the symphysis pubis, beneath the lower border of Poupart's ligament, to become the femoral artery.

RELATIONS.—Anteriorly: peritoneum, subperitoneal fascia, termination of the ilium on the right side; sigmoid flexure and colon on the left side; genital branch of the genitocrural nerve, circumflex iliac vein, spermatic artery and vein, ovarian vessels (in female), ureter, vas deferens, external iliac, lymphatic vessels and nodes. Posteriorly: external iliac vein, internal border of psoas muscle, iliac fascia. Internally: external iliac vein, peritoneum, vas deferens, ovarian vessels (in female). Externally: psoas muscle, iliac fascia.

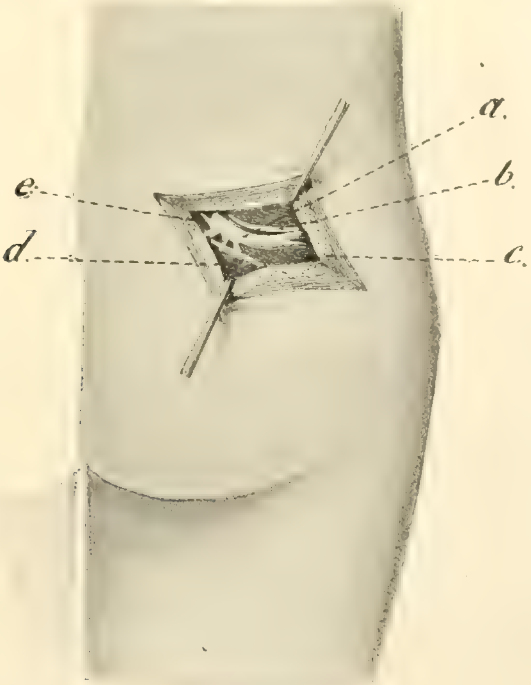


FIG. 280.—Exposure of Gluteal Artery. (After Kocher.) *a*, Gluteal artery; *b*, superior gluteal nerve; *c*, gluteus medius muscle; *d*, pyriformis muscle; *e*, gluteus maximus muscle.

The Retroperitoneal Method. (Figs. 281 and 282.)—The linear guide is the same as that for the common iliac. The incision starts over the external iliac artery, about 1.3 cm. (one-half inch) above Poupart's ligament, and runs parallel to the ligament as far as to the anterior superior spine of the ilium. It is then prolonged upward in the cleavage line of the external oblique as far as is necessary. Incise the skin and the superficial fascia, exposing the aponeurosis of the external oblique, and ligate blood-vessels when encountered. Divide the aponeurosis in its cleavage line as far toward or beyond the anterior superior spine of the ilium as is necessary for easy manipulation. Retract the cut edges well apart and separate the internal oblique from its attachment to the outer half of Poupart's ligament. The branches of the iliac, hypogastric, and the ilioinguinal nerves should be carefully displaced, either upward or downward. Detach the transversalis from the outer part of Poupart's ligament and as far beyond as necessary, dividing its fibres transversely. Carefully guard the deep circumflex iliac artery and vein and the genitocrural nerve. The transversalis fascia is then exposed and divided over the artery in the same direction as the previous incision. The artery is carefully isolated after one has made sure that the deep epigastric, the main source of collateral circulation, is properly guarded. The peritoneum is pushed backward and upward from the vessel and held out of the way by retractors; the sheath of the artery is opened and the needle is passed from the vein to the inner side of the artery, care being taken that the anterior crural nerve shall not be included in the ligature. The ligature should be placed about one inch and one-quarter above Poupart's ligament. The divided muscles are united at their separate margins with buried catgut suture.

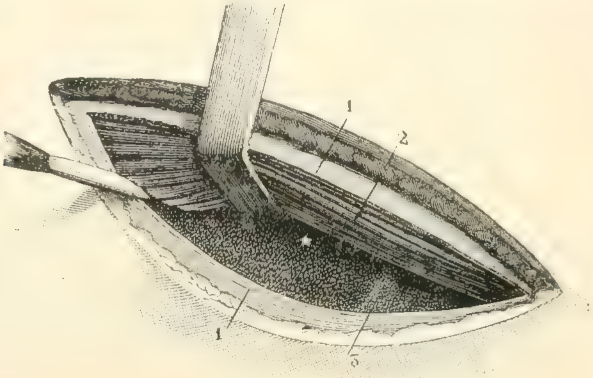


Fig. 281.—Ligature of the External Iliac Artery on the Right Side. (After Farabeuf.) The obliquus internus and the transversalis muscles are being divided along the line where they are a attached to the pelvic bone, and their inferior border is being pulled upward by means of a retractor, in order to expose to view the deeper structures. 1, 1', Cut edges of the aponeurosis of the obliquus externus; 2, inferior border of the obliquus internus and the transversalis muscles; 3, fascia transversalis lifted up somewhat at this point by the epigastric blood-vessels; *, place where an opening should be made in the fascia transversalis for the purpose of gaining access to the iliac artery.

Transperitoneal Method.—This is practically the same as that which is used in the similar method of exposing the common and internal iliac arteries. (See page 508.) In operations for aneurism the transperitoneal method is preferred by many to the retroperitoneal method, because there is less likelihood of injuring the aneurismal sac or of interfering with the deep epigastric anastomosis. However, the extraperitoneal route is an admirable way of ligating the vessel, provided there is room enough to reach the artery without injuring the sac.

Precautions.—Care should be taken, in the extraperitoneal method, not to injure the peritoneum, spermatic cord, iliac vein, deep epigastric artery, circumflex iliac vein, or the sac of the aneurism.

Deep Epigastric Artery.—Surgical Anatomy.—This artery generally arises from the inner side of the external iliac about 6 mm. (one-fourth inch) above Poupart's ligament. It descends to Poupart's ligament and then ascends along the inner border of the internal abdominal ring, passing behind the inguinal canal and slightly above and external to the femoral ring; then it continues upward and inward toward the umbilicus, passing between the transversalis fascia and the peritoneum. It courses from the external abdominal ring to the semilunar fold of Douglas, and then passes upward between the rectus muscle and its sheath, to enter this muscle and anastomose with the epigastric branch of the internal mammary. It is accompanied by two veins. In the loop formed at Poupart's ligament we find the vas deferens in the male and the round ligament in the female, passing on their way to the internal ring.

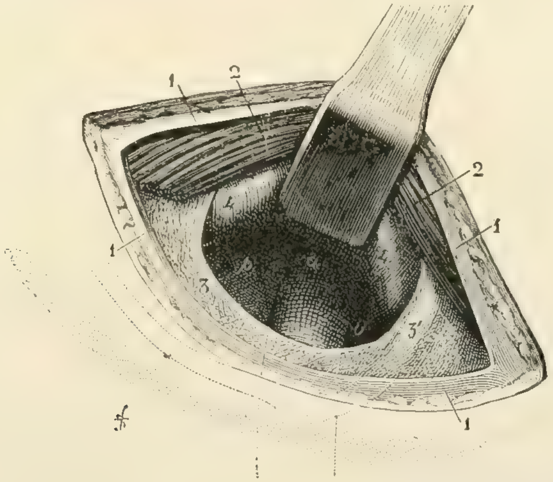


Fig. 282.—Last Step in the Operation of Ligaturing the External Iliac Artery on the Right Side. (After Farabeuf.) 1, 1, 1, 1, Aponeurosis of the obliquus externus; 2, 2, lower border of the obliquus internus and transversalis muscles, which have been pulled upward out of the way after their external attachments to the pelvic bone had been divided; 3, 3′, fascia transversalis, in which an opening has been established; at 3′ one sees faintly how this fascia is lifted up by the underlying epigastric blood-vessels; the numbers 4, 4, are placed on the peritoneal cul-de-sac, which is being pulled upward by the retractor. At the very bottom of the wound may be seen the external iliac artery (*a*) and, next to it on the inner side, the vein (*v*); the psoas muscle (*p*) is masked by its overlying aponeurosis.

Operation.—The linear guide is represented by a line drawn midway between the symphysis pubis and the anterior superior spine of the ilium toward the umbilicus. The vessel is usually ligated near its origin. The operation is the same as that for ligation of the external iliac artery by the retroperitoneal route, except that the incision is shorter and is carried down upon the epigastric. The external iliac is exposed and its epigastric branch is sought for.

Femoral Artery.—Out of fifteen patients operated on under aseptic precautions, one died. Before the aseptic period about one out of three patients died.

John Hunter, in 1785, first ligated the vessel for popliteal aneurism. Dessault applied Brasdor's method of proximal ligation in the case of a popliteal aneurism. Carnochan, of New York, in 1851, ligated the vessel for elephantiasis Arabum.

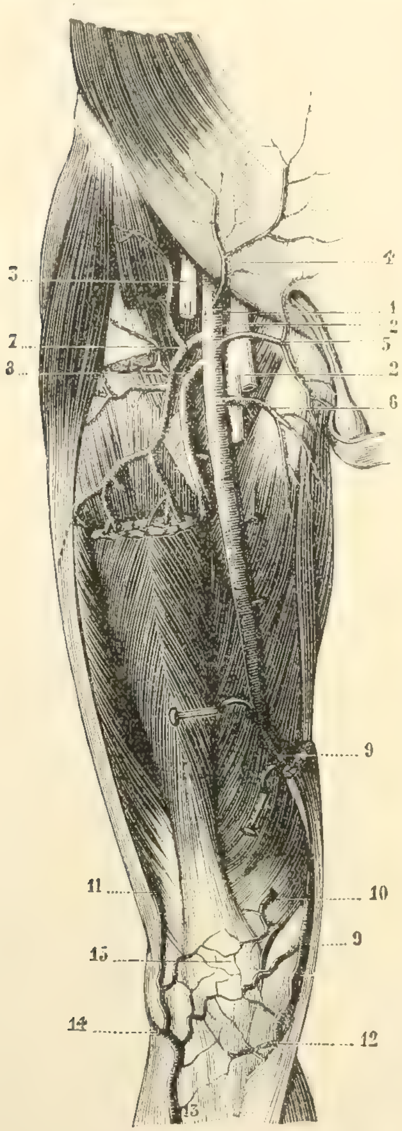


Fig. 283.—Femoral Artery and Its Branches. (After Testut.) 1, Trunk of the femoral artery; 2, femoral vein, with (2′) the long saphenous vein; 3, crural nerve; 4, subcutaneous abdominal artery; 5, superficial external pudic artery; 6, deep external pudic artery; 7, artery supplying the quadriceps muscle; 8, profunda artery; 9, anastomotica magna artery; 10, superior internal articular artery; 11, superior external articular artery; 12, inferior internal articular artery; 13, anterior tibial recurrent artery; 14, inferior external articular artery; 15, arterial circle of the knee.

Surgical Anatomy.—The femoral artery is a continuation of the external iliac artery. It arises at the lower border of Poupart's ligament, midway between the anterior superior spine and the symphysis pubis, and descends superficially along the inner side of the thigh to the opening in the adductor magnus muscle. At the junction of the lower and middle thirds of the thigh it passes through the canal of this muscle to the popliteal space, where it becomes the popliteal artery. In its upper third the artery traverses Scarpa's triangle from its centre to its apex; in its lower third it passes through Hunter's canal. The vein lies behind and external to the artery; and the long saphenous nerve is external to the blood-vessels. The portion above the origin of the profunda (one and one-half to two inches in length) is the common femoral; that below, the superficial. (Plate XXVIII, Fig. 2; Fig. 283.)

Relations of the Common Femoral.—Anteriorly: skin, superficial fascia, superficial inguinal lymph node, iliac portion of the fascia lata, crural branch of the genitocrural nerve, circumflex iliac vein, and at times the superficial epigastric vein. Posteriorly: the continuation of the iliac fascia into the femoral sheath, pubic portion of the fascia lata, psoas and pectineus muscles, and the capsule of the hip joint. Externally: the anterior crural nerve. Internally: the femoral vein.

Relations of the Superficial Femoral Artery in Scarpa's Triangle.—Anteriorly: skin, superficial fascia, crural branch of the genitocrural nerve, internal cutaneous nerve, and deep fascia. Posteriorly: femoral and profunda veins, profunda artery, pectineus and adductor longus muscles. Externally: long saphenous nerve. Internally: femoral vein. In Hunter's canal the relations are as follows:—Anteriorly: skin, superficial and deep fascias, sartorius muscle, internal saphenous nerve, and the aponeurotic roof of Hunter's canal. Posteriorly: vastus internus and adductor muscles, femoral vein, which runs to the outer side in the lower part of the canal. Internally: above, the adductor longus, and below, the adductor magnus. Externally: vastus internus, and the femoral vein in the lower part of the canal.

Linear Guide.—It is represented by a line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis to the adductor tubercle of the internal femoral condyle. At the time of drawing this line the hip should be slightly flexed and the thigh abducted and rotated outward.

Operation.—The common femoral may be ligated at the base of Scarpa's triangle, but this is rarely done because of the proximity of the large vessels. The operation of election is ligature of the superficial femoral at the apex of Scarpa's triangle.

(*a*) *Ligation of the Common Femoral at the Base of Scarpa's Triangle.* (Plate XXVIII, Fig. 2.)—The artery is located by its linear guide. The patient should be supine, with the hip slightly flexed and the thigh abducted and rotated outward. The incision starts just below Poupart's ligament and extends downward about two inches along the linear guide. (Fig. 283.) Skin and superficial fascia are divided, and care should be taken to avoid the superficial arteries and veins. Divide the fascia lata: open and expose the sheath of the vessels, preserving the crural branch of the genitocrural nerve, which lies on the sheath a little external to the artery. The femoral vein is to the inner side of the artery, and the needle should be passed between it and the vein, care being taken not to include the anterior crural nerve, which lies external to the artery and outside the sheath.

The vessel can be exposed in this position by an incision made just below the lower border of Poupart's ligament and parallel to it. The incision previously described is, however, preferable. The chief dangers from the operation are gangrene and secondary hemorrhage from infection. The latter danger is best avoided by ligating the branches of the vessel contiguous to the site of the operation. This precaution, however, increases the danger of gangrene. When possible, therefore, it is better to ligate the external iliac than to tie the femoral in this situation.

(*b*) *Ligation of the Superficial Femoral at the Apex of Scarpa's Triangle.* (Plate XXVIII, Fig. 2.)—An incision, about 7.5 cm. (three inches) in length, is made along the linear guide, the centre of which is located about four inches below Poupart's ligament. Incise the skin, superficial fascia, and the fascia lata, ligating or drawing to one side any branches of the internal saphenous vein met with. Retract outward the sartorius muscle, which is identified by its fibres running downward and inward. The long saphenous and internal cutaneous nerves are displaced from in front of the artery to one side. Clear the sheath and open it, passing the needle between the artery and the vein, which lies behind and internal to the former.

(*c*) *Ligation of the Superficial Femoral in Hunter's Canal.* (Figs. 284 and 285.) —This operation is not often performed. The artery is located by its linear guide. The limb should be rotated outward, with the leg flexed upon the thiga and the thigh upon the pelvis. An incision, three and one-half inches in length, is made along the guide over the middle third of the thigh. The skin, superficial fascia, and fascia lata are divided. Retract inward the sartorius muscle and expose the roof of Hunter's canal and incise it. The long internal saphenous nerve will be found in front of the sheath of the vessels. Open the sheath and pass a needle between the artery and the vein.

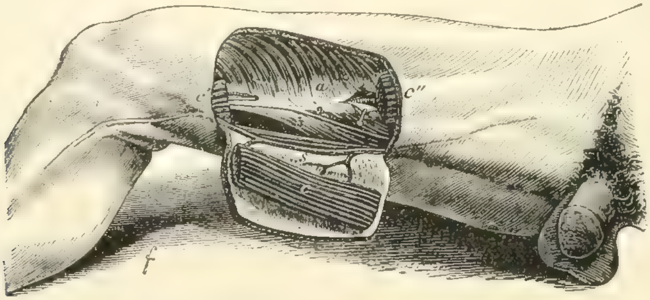


Fig. 284.—The Canal of Hunter. (After Farabeuf.) A lid-like flap, composed of skin and the sartorius muscle (*c*), has been cut in the inner aspect of the right thigh and turned down in such a manner as to expose the canal to view. *s*, Saphenous vein skirting the rectus internus muscle; *c'* and *c''*, ends of the divided sartorius muscle; *a*, vastus internus muscle, with the tendinous aponeurosis that covers its fibres; 3, tendon of the adductor longus; 2, adductor brevis; a little to the left of *c''* in the picture will be seen an opening which has been made in Hunter's canal for the purpose of exposing to view the femoral artery—the margins of the opening are held back by two pins. Farther down, near *c*, the nerve may be seen issuing from the canal.

While the artery in this situation may be located by the linear guide described above, it is more readily approached in the following manner: Flex the thigh on the pelvis, and the leg on the thigh, and rotate the limb outward; then make an incision about three inches in length over the tendon of the adductor magnus, the centre of which incision should correspond to the junction of the middle and lower thirds of the thigh. Hunter's canal, covered by the aponeurotic tissue forming its roof, is thus exposed. The canal is carefully opened, the saphenous nerve is pushed aside, and the needle is passed from without inward, thus avoiding the femoral vein which in this situation lies posteriorly and externally to the artery.

General Considerations.—Occasionally the artery is double, though forming a single popliteal artery, and occasionally it passes behind instead of in front of the thigh. In case the artery is double, the vessel first exposed will be smaller than is usual, and ligature of it will not affect the distal circulation as it should were the vessel normal. If the artery cannot be found in the front of the thigh, it should be searched for behind. Deep pressure usually locates it. The vein at times maintains an abnormal relation to it. The vein at the apex of Scarpa's triangle has been found internal to the artery and, in Hunter's canal, posterior to it.

Profunda Artery (arteria profunda femoris).—This artery is the largest branch of the femoral artery and almost equals it in size. It arises from the external and superior aspect of the femoral, about 4 cm. (one to two inches) below Poupart's ligament descends, first, externally to the superficial femoral and then posteriorly to the femoral artery and vein, to the inner side of the femur, and, finally, runs beneath the adductor longus and terminates at the lower third of the thigh, piercing the adductor magnus. (Fig. 283, 8.)

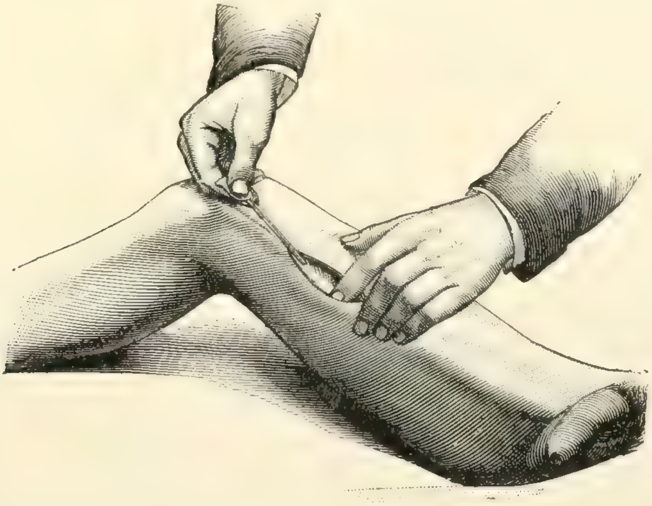


Fig. 285.—Ligature of the Femoral Artery in Hunter's Canal. (After Farabeuf.) The leg has been flexed and the thigh abducted. A longitudinal incision has been made through the skin and subjacent connective tissue over the site of Hunter's canal. The index finger of the surgeon's left hand rests on the tendincus cord on the inner side of the thigh. With his right hand he has introduced the end of the steel director into the opening from which the saphenous nerve emerges, and is pushing it upward beneath the aponeurosis, which constitutes the inner wall of Hunter's canal.

Relations.—Anteriorly: near its origin, skin, superficial fascia, deep fascia, and branches of the anterior crural nerve; lower down, femoral and profunda veins; and at its lowest portion, the adductor longus muscle. Posteriorly: iliacus, pectineus, adductor brevis, and adductor magnus muscles. Externally: vastus internus. Internally: the pectineus, and the angle of juncture of the adductor brevis and the vastus internus.

Operation.—The linear guide to the main vessel suffices for this artery. The ligation is performed usually near its origin. The patient is supine, with his limb extended and parallel to its fellow, or, better, slightly flexed and rotated outward. An incision 5 or 6 cm. (two or two and one-half inches) in length is made in the line of the main artery, with the centre of the incision about 4 cm. (one inch and one-half) below Poupart's ligament. Incise skin, superficial fascia, and fascia lata; retract the sartorius and rectus muscles, guarding the branches of the anterior crural nerve, which are in close relation with the rectus muscle. The trunk of the common femoral will then be exposed. Its profunda branch is sought for and recognized by its size, by its course, which runs downward and outward, and by the fact that it is given off from the posterior and external surface of the femoral. Its external circumflex branch is its first and largest branch, and it passes under the rectus muscle. When the artery is freed, the ligature may be passed.

Popliteal Artery.—This artery is seldom ligated on account of the difficulty of reaching it and because the conditions that call for its ligature are better served by ligation of the superficial femoral artery. Of the ten cases of ligature reported, three terminated fatally. Of the five patients operated on under aseptic precautions, all recovered.

Surgical Anatomy.—The popliteal artery is a continuation of the femoral; it extends from the aponeurotic opening in the adductor magnus muscle downward and outward to the centre of the popliteal space, and then descends vertically to the inferior border of the popliteus muscle, where it divides into anterior and posterior tibial arteries. (Plate XXVIII, Fig. 4; Fig. 278, 9.)

Relations.—Anteriorly: popliteal surface of the femur, posterior ligament of the knee joint, and the popliteus muscle. Posteriorly: semimembranosus, above; skin, superficial and deep fascias, over its centre; the internal head of the gastrocnemius and the aponeurotic arch of the soleus, below. The popliteal vein lies posterior to the artery throughout its course, crossing it obliquely from the outer to the inner side. The internal popliteal nerve lies behind the artery and vein, crossing the vessels at their centre from the outer to the inner side. Externally: external condyle, biceps, above; outer head of the gastrocnemius muscle and the plantaris muscle, below. Internally: semimembranosus, above, and the internal popliteal nerve and the inner head of the gastrocnemius muscle, below.

Linear Guide.—The line begins above at a point a little to the inner side of the middle of the upper portion of the popliteal space and passes downward midway between the condyles of the femur.

Operation. (Plate XXVIII, Fig. 4.)—A vertical incision is made over the middle of the popliteal space behind the knee joint, care being taken to avoid injuring the saphenous vein in the lower part of the incision. The incision is continued through the areolar tissue to the inner side of the popliteal vein and the communicans fibularis nerve. The internal popliteal nerve is first encountered and is drawn outward, revealing the popliteal vein, which is closely bound to the subjacent popliteal artery. The popliteal artery lies upon the fat that covers the femoral triangle above and the popliteus muscle below.

Ligating by this method is easiest of accomplishment when the patient is prone. If he is supine, the thigh should be strongly flexed and rotated outward.

Ligature of the Popliteal from the Inner Side of the Thigh.—The patient is supine and the thigh is slightly flexed, fully abducted, and rotated outward. The knee is flexed at a right angle. The incision, which is about three inches in length, and which begins at a point opposite the juncture of the middle and lower thirds of the thigh, runs parallel to, and immediately behind, the tendon of the adductor magnus muscle. Divide the skin and the superficial and deep fascias, avoiding the anterior branch of the interal cutaneous nerve. Expose and retract backward the edge of the sartorius muscle and the internal saphenous vein. The adductor magnus tendon is drawn forward and the semimembranosus backward, and the artery will be found between these two structures near the bone. The popliteal nerve and vein, being posterior to the artery, are not as a rule brought into view.

Anterior Tibial Artery.—This artery is the smaller of the terminal branches of the popliteal and arises at the lower border of the popliteus muscle. Passing forward between the two heads of the tibialis posticus it passes through the opening in the upper part of the interosseous membrane, between the tibia and the fibula, and descends to the deep part of the front of the leg, first on the anterior surface of the interosseous membrane, then on the tibia, and finally in front of the ankle joint, passing under the anterior annular ligament, where it becomes the dorsalis pedis artery. It is accompanied by two veins. Throughout its lower three-fourths it is accompanied by the anterior tibial nerve, which lies external to it except in the middle of the leg, where it slightly overlaps it. (Plate XXIX, Fig. 4.)

Relations.—Anteriorly: skin, superficial and deep fascias, anterior tibial nerve (at its middle), tibialis anticus, and the extensor longus digitorum, above; and the extensor proprius pollicis muscle and the anterior annular ligament, below. Posteriorly: interosseous membrane throughout its upper third; the tibia and the ankle joint throughout its lower two-thirds. Exteriorly: the anterior tibial nerve and the extensor longus digitorum, above; and the extensor proprius hallucis, throughout its middle third. Internally: the tibialis anticus throughout its upper two-thirds. The extensor proprius hallucis crosses the lower part of the artery.

Linear Guide.—The linear guide is a line extending from the head of the fibula to a point midway between the malleoli.

Operations.—The artery may be ligated in its upper, its middle, or its lower third.

Ligation of the Upper Third.—The incision is carried downward, along the linear guide, for a distance of three inches. Divide the skin and the superficial and deep fascias, exposing the outer edge of the tendinous origin of the tibialis anticus muscle, which corresponds to the intermuscular space between the tibialis anticus and the extensor longus digitorum. The space is widened by the finger or the handle of the scalpel down to the interosseous membrane, through which the artery passes from behind forward about one-half inch below the head of the fibula. The anterior tibial nerve does not reach the artery here; it joins it from the outer surface of the extensor longus digitorum. The artery and the attendant veins lie upon the interosseous membrane. If the veins cannot be separated from the artery without too much damage, they may be included in the ligature. Ligaturing at this situation is tedious and difficult and should not be attempted unless demanded.

Ligation of the Middle Third.—An incision, 3 cm. (a little more than one inch) in length, is made externally to the anterior edge of the tibia, along the furrow at the outer border of the tibialis anticus muscle. The skin and fascia are divided, the fascia here being represented by a white line, and the interval between the tibialis anticus muscle on the one hand, and the extensor longus digitorum and the extensor proprius hallucis on the other, is widened down to the interosseous membrane, upon which will be found the artery between the muscular fibres of the tibialis anticus and the extensor proprius hallucis. The anterior tibial nerve lies anterior to the artery. The operation will be facilitated by flexing the foot.

Ligation of the Lower Third.—An incision, from 5 to 7.5 cm. (two to three inches) in length, is made along the outer edge of the tendon of the tibialis anticus muscle, the centre of the incision corresponding to the centre of the lower third of the leg. The incision is made between the tendons of the tibialis anticus and the extensor proprius hallucis muscles. After the skin and the strong fascia have been divided, and the foot flexed, the tendon of the extensor proprius hallucis is exposed and drawn outward. The finger is now passed down toward the external surface of the tibia until it encounters the anterior tibial nerve, just external to the tendon of the tibialis anticus muscle.

Dorsalis Pedis Artery.—This artery, which is a continuation of the anterior tibial, extends from the bend of the ankle to the first intermetatarsal space, traversing the foot along its tibial side. At the interspace it passes into the sole between the two heads of the first dorsal interosseous muscle, to become the communicating artery.

Surgical Anatomy.—The relations of the artery are the following: Anteriorly: skin, superficial and deep fascias, annular ligament, extensor proprius hallucis, the innermost tendon of the extensor brevis digitorum; posteriorly: astragalus, scaphoid, and internal cuneiform bones, and the ligaments of the first and second metatarsals; externally: the innermost tendon of the extensor longus digitorum above the anterior tibial nerve, and the innermost tendon of the extensor brevis digitorum below this nerve; internally: extensor proprius hallucis. (Fig. 286.)

Linear Guide.—This is a line running from a point midway between the malleoli to the upper end of the first interosseous space.

Operation. (Fig. 286.)—The dorsalis pedis artery may be ligated at the dorsum of the tarsus, and its dorsal extension (the dorsalis hallucis) at the first interosseous space.

Ligation at the Dorsum of the Tarsus.—The skin is divided longitudinally, beginning below the annular ligament midway between the malleoli, by an incision 2.5 to 5 cm. (one to two inches) in length. The internal branch of the musculocutaneous nerve is found running in the direction of the incision and is drawn outward. The deep fascia is divided and the innermost tendon and the muscular fibres belonging to the extensor brevis digitorum are drawn downward and outward, exposing to view the artery which lies upon the tarsal ligaments. The anterior tibial nerve lies external to the artery. The artery is accompanied by two veins. Care should be taken not to open the sheaths of the tendons. This operation should not invade the annular ligament unless it is absolutely necessary.

Ligation at the First Interosseous Space.—The incision is made through the skin and fascia, between the bases of the first and second metatarsal bones. The internal branch of the musculocutaneous nerve, and the internal saphenous vein, are drawn outward and guarded. The artery, with the cutaneous termination of the anterior tibial nerve lying upon it, is found emerging from under the innermost tendon of the extensor brevis digitorum. This tendon should be retracted outward.

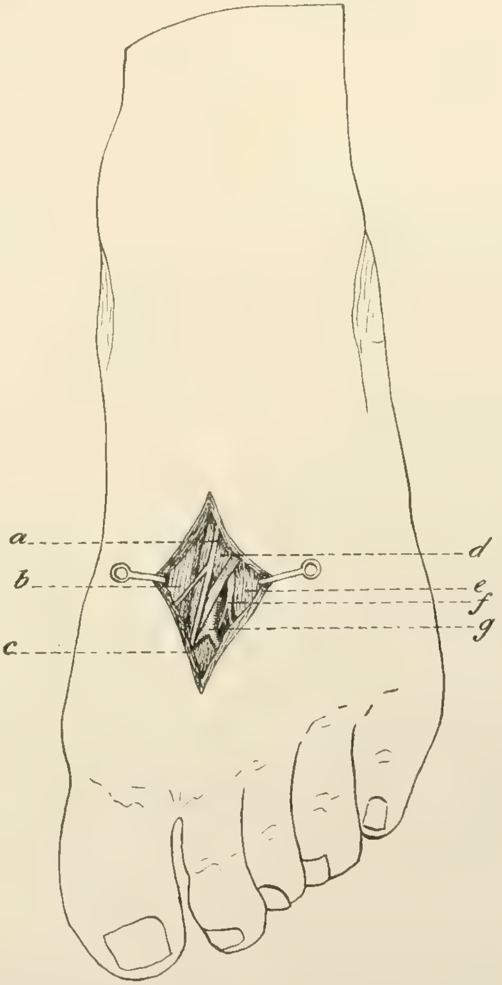


Fig. 286.—Ligature of the Dorsalis Pedis Artery. (After Kocher.) *a*, Musculocutaneous nerve; *b*, external longus hallucis tendon; *c*, first dorsal interosseous muscle; *d*, external brevis hallucis muscle; *e*, external brevis digitalis muscle; *f*, anterior tibial nerve; *g*, dorsalis pedis artery.

Posterior Tibial Artery.—This artery is the larger of the terminal divisions of the popliteal artery. It extends from the lower border of the popliteus muscle deeply down the inner side of the back of the leg to midway between the tip of the internal malleolus and the os calcis, at which point it divides into external and internal plantar branches. It is accompanied by two veins. The posterior tibial nerve crosses the artery, from its outer to its inner surface, about 2.5 to 4 cm. (one to one and one-half inches) below the internal border of the popliteus muscle; then descends along its external aspect. (Plate XXIX, Fig. 5.)

Relations.—Anteriorly: tibialis posticus, flexor longus digitorum, tibia, internal lateral ligaments of the ankle joint; posteriorly: skin, superficial fascia, gastrocnemius, soleus, deep intermuscular fascia, and posterior tibial nerve. Its lower third is superficial, being covered only by skin and superficial fascia. Externally, it is related to the posterior tibial nerve along its lower three-fourths; internally, to the posterior tibial nerve along its upper fourth. At the ankle joint the artery lies under the internal annular ligament and the abductor hallucis, resting upon the internal lateral ligament of the ankle joint. The tibialis posticus and the flexor longus digitorum are anterior to it, and the posterior tibial nerve and the flexor longus hallucis are posterior and external to it.

Linear Guide.—This is represented by a line drawn from a point 5 cm. (two inches) below the centre of the popliteal space to a point midway between the tip of the internal malleolus and the tuberosity of the os calcis. The upper portion curves slightly inward from this line.

Operations.—This artery may be ligated in its upper, its middle, or its lower third.

Ligature in Its Upper Third, Above the Origin of Its Peroneal Branch.—The incision, which is about 7.5 cm. (three inches) in length, and is made in a downward direction, begins at the level of the head of the fibula, three finger-breadths below the popliteal crease. Divide the skin and fascia, and, in dividing the latter, be careful to draw the short saphenous vein and the communicans tibialis nerve outward. The line of juncture of the heads of the gastrocnemius are sought for, and the tendinous raphe is divided. The large vessels and nerves which supply the heads of the gastrocnemius are drawn aside. The soleus muscle is found beneath the outer head of the gastrocnemius, extending obliquely downward and inward; and, resting upon it, is the slender tendon of the plantaris muscle, which runs in a similar direction. In order to make it easier to reach the posterior tibial artery the edge of the soleus should be drawn downward or nicked transversely. The posterior tibial vein and nerve should be drawn outward, and the needle then passed around the artery.

Ligation of the Middle Third. (Plate XXIX, Fig. 5.)—An incision, about 7.5 cm. (three inches) in length, is made along the linear guide parallel with and posterior to the internal border of the tibia, along its middle third. Incise skin, superficial and deep fascias, guarding the internal saphenous vein and nerve; retract outward the edge of the gastrocnemius and divide the soleus from its attachment to the tibia and retract it outward; then divide the intermuscular fascia, exposing the flexor longus digitorum. Follow this muscle until about opposite the external border of the tibia. The following structures will be encountered in the order enumerated:—the internal accompanying vein, the posterior tibial artery, the external accompanying vein, the posterior tibial nerve. These vessels and the nerve will be found between the tibialis posticus and the flexor longus digitorum. The knee and foot should be flexed in order to relax these structures, and the needle should be passed between the artery and the nerve. If the accompanying veins cannot be separated from the artery without injuring them they may be included in the ligature.

Ligature of the Lower Third.—An incision, 5 cm. (two inches) in length, is made midway between the inner border of the tibia and the inner border of the tendo Achillis. An incision is made in the line of the artery with its centre over the lower third of the leg. Incise down to and through the deep fascia which binds the flexor tendons, and the artery will be found between the flexor longus digitorum and the flexor longus hallucis. It is surrounded by its venae comites, with the posterior tibial nerve external to it.

Ligation Behind the Inner Malleolus. (Plate XXIX, Fig. 3.)—A curved incision, about 5 cm. (two inches) in length, is made midway between the internal malleolus and the tuberosity of the os calcis. Divide the annular ligament over the vessel, and in the space between the flexor longus digitorum and the flexor longus hallucis will be found the artery surrounded by its venae comites, with the nerve lying against its external surface. Care should be taken not to open the sheaths of the tendons.

Peroneal Artery.—This artery arises, in the upper third of the leg, from the posterior tibial artery. Its course is indicated by a line continued downward from the popliteal artery along the inner border of the posterior surface of the fibula.

Relations.—Anteriorly: tibialis posticus and the aponeurosis between the tibialis posticus and the flexor longus hallucis; posteriorly: the soleus and the flexor longus hallucis; externally, the fibula and the flexor longus hallucis; internally, the flexor longus hallucis.

Operations.—The linear guide for ligaturing the vessel is represented by a line drawn from the posterior border of the head of the fibula to a point midway between the external malleolus and the tendo Achillis. The artery may be ligated either in the upper or in the lower part of the leg.

Ligation in the Upper Part of the Leg.—After the foot has been extended an incision, 7.5 cm. (three inches) in length, is made parallel to and just back of the posterior surface of the fibula, behind the peroneus longus muscle. Divide skin and superficial fascia, exposing and drawing to one side the communicans fibularis nerve; then divide the deep fascia behind the peroneus muscle. Detach the soleus from its fibular origin and from the glistening tendinous fascia covering the flexor longus hallucis, which rests upon the posterior surface of the bone. The dissection is continued deeply between the bone and the flexor longus hallucis until the oblique internal border is reached, and the artery will be found just previous to its entering the body of the muscle.

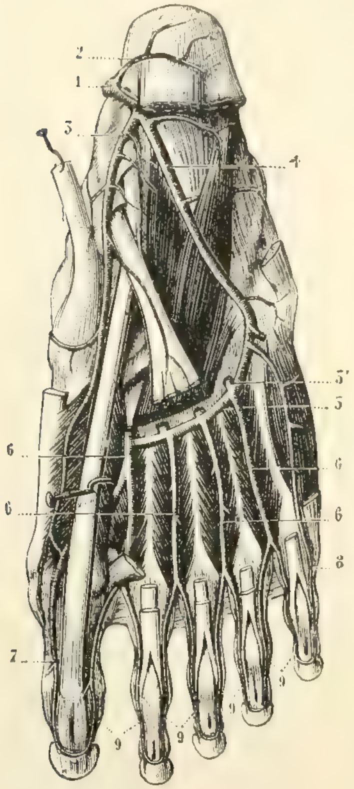


Fig. 287.—Distribution of the Arteries in the Plantar Region. (After Testut.) 1, Posterior tibial; 2, calcaneal branch of the posterior tibial; 3, internal plantar; 4, external plantar; 5, plantar arch, with (5′) one of the perforating branches; 6, 6, digital branches; 7, internal collateral of the big toe; 8, external collateral of the little toe; 9, 9, the other collateral branches of the toes.

Ligation in the Lower Half of the Leg.—An incision having the same direction and length as that described for ligature in the upper part of the leg, is made over the lower half of the artery. Divide the tissues down to the outer border of the soleus muscle, and draw the latter inward, thus exposing the flexor longus hallucis covered by a tendinous fascia. Separate the latter muscle from its posterior fibular attachment, and at the outer border of the tibialis posticus muscle the artery will be found.

External Plantar Artery.—This is the larger of the terminal branches of the posterior tibial artery. It arises at the ankle joint, just beneath the internal annular ligament, and passes obliquely forward and outward from the inner ankle, across the sole of the foot, to the base of the fifth metatarsal bone, where it curves inward and forward to the beginning of the first interosseous space. At the latter point it anastomoses with the communicating branch of the dorsalis pedis artery, forming the plantar arch. (Fig. 287.)

Relations.—Superiorly: os calcis, flexor accessorius, flexor minimi digiti; inferiorly: skin, superficial and plantar fascias, abductor hallucis, flexor brevis digitorum, and the abductor minimi digiti. The artery lies between the flexor brevis digitorum and the abductor minimi digiti. It is accompanied by venæ comites and by the external plantar nerve.

Operations.—The artery runs in a line drawn from midway between the internal malleolus and the tuberosity of the os calcis to the fourth toe. An incision, which starts immediately in front of the heel, and which is about 6 cm. (two and one-half inches) in length, is made along the guiding line. This incision should extend to and include the plantar fascia; and between the adjacent edges of the flexor brevis digitorum and the abductor minimi digiti will be found the artery.

The artery may also be ligated at its origin. In this case the incision, about a finger's breadth beneath and anterior to the sustentaculum tali, is made horizontally backward along the lower border of the foot, above the prominence of the abductor hallucis muscle. Divide the tissues down to the above-named muscle, which is exposed and drawn downward from the subjacent deep fascia. Divide the latter, and the artery will be found just opposite to a line let fall from the posterior border of the inner malleolus. The posterior tibial nerve lies just below the artery.

Internal Plantar Artery. (Fig. 287.)—This artery is the smaller of the terminal branches of the posterior tibial. It passes forward and along the inner side of the sole to the first interosseous space, where it anastomoses with the fifth plantar digital branch of the communicating branch of the dorsalis pedis artery.

Relations.—The artery lies between the abductor hallucis and the flexor brevis digitorum, and toward the end it is covered only by skin and fascia.

Operations.—Ligation at its origin is the same as the operation for ligation of the external plantar artery at its origin. (See above.)

Ligation in the Sole of the Foot.—The linear guide is represented by a line drawn from the inner border of the heel to the great toe. An incision, about 6 cm. (two and one-half inches) in length, is made along the line of the artery, down through the strong plantar fascia, and the artery will be found between the adjacent edges of the flexor brevis digitorum and the abductor hallucis.

Plantar Arch.—Relations.—This is covered by skin, superficial and plantar fascias, flexor brevis digitorum, the tendons of the flexor longus digitorum, the lumbricales muscles, branches of the internal plantar nerve, and the adductor hallucis muscle. The arch rests on the interosseous muscle and the second, third, and fourth metatarsal bones.

Operation.—The line of the arch runs from the base of the metartasal bone of the second toe to that of the little toe. An incision, about 6 cm. (two and one-half inches) in length and following a backward and outward direction, is made along the guiding line. Incise the skin, fatty tissue, and the plantar fascia; separate and draw apart the tendons of the flexor brevis and flexor longus digitorum muscles; draw outward toward the little toe the internal plantar nerve. Then the long flexor tendon of the first lumbrical muscle and the short flexor tendon of the second toe are drawn outward, exposing the strong adductor hallucis muscle. Cut through this muscle, and the artery will be found at the first interosseous space, where it joins the dorsalis pedis. The artery rests upon the interosseous muscle. This vessel need not be ligated except to arrest hemorrhage from direct injury, when it is tied in the wound at both ends. To obviate secondary hemorrhage in this locality it is usual to ligate the nearest collateral branches.

III. INTERMEDIATE LIGATION, OR LIGATURE EN MASSE.

As a rule, ligature *en masse* is restricted to the control of parenchymatous hemorrhage such as comes from capillary oozing, or from inaccessible sources. It is performed by entering a needle fully curved and threaded with catgut to one side of the site of the hemorrhage and passing it more or less completely around the area of bleeding or around the vessels supplying the part with blood. The needle should emerge close to the point of entrance, and the bleeding surface should be controlled by tying the ligature until all hemorrhage stops. In hemorrhage from a large area, several ligatures, each of them taking in a part of the vascular supply of the bleeding surface, may be employed. Enough ligatures should be used to secure complete hæmostasis.

IV. LIGATURE OF VEINS IN THEIR CONTINUITY.

General Considerations.—Surgery of the venous system is still in an unsatisfactory state, but during recent years it has taken a long step forward. Reports upon the work done on the great venous trunks, delivered before the French Congress of Surgery held in Paris in October, 1906, demonstrate the advance made in this important surgical field. Lejars' remarkable report of operations performed on the large venous trunks shows clearly the rapid strides the modern surgeon is making in the preservation of vascular permeability in injuries of the great venous trunks. Up to within a short time ago this field lay beyond the pale of surgery. The frequency and gravity of the septic thrombus forbade general interference. Even the ligature which a wound of a vein demanded was considered undesirable if not hazardous. But with more definite knowledge, aseptic methods, improved operative technique, and knowledge of the healing properties of serous membranes, a form of conservative surgery is fast bringing us to a realization of the number of lives that can be saved by the utilization of means justified by modern investigation. Before the aseptic period, operations upon veins were dangerous, not only because of hemorrhage and air embolisms, but also because of the frequency with which fatal complications—such as phlebitis, septic thrombosis, and pyæmia—occurred.

Operative Technique.—In operations upon the veins the same general precautions should be observed as those which have already been recommended in the section relating to operations upon the arteries. Ligature may be performed either for the permanent or for the temporary arrest of the circulation of the blood in the continuity of the vein. In permanent ligatures of the veins for hemorrhage double ligatures must be applied—one ligature on each side of the wound—and care should be taken to see that no anastomosing branch communicates with the wounded vein between the ligatures. If such an anastomosing branch be found, it also will have to be ligated in order to prevent secondary hemorrhage.

For the purposes of ligature plain or chromicized catgut, ranging in size from No. 00 to No. 3, serves best. In cases in which the ligature of necessity has to be placed close to the divided end of a large vein, and when there is danger that it may slip, twisted silk should be used instead of catgut. When a vein is to be sutured, a No. 00- or an No. 0-sized silk ligature, which just fits the eye of the needle, should be employed. Schede uses fine catgut, claiming for it the advantage that when it swells it better occludes the hole in the vein made by the needle. In the suturing of veins the sutures should be placed close together and as close to the lips of the wound as is possible. The wound should be closed with a hem suture and care should be taken to see that the edges of the wounded vein do not turn in. By observing this precaution we avoid narrowing the lumen of the vein and the chances of thrombosis are thus lessened.

V. LIGATION OF INDIVIDUAL VEINS.

In describing the operations for ligature of individual veins we shall consider only the larger trunks. Injuries of the portal vein, of the venæ cavæ (when wounded at the level of or above the renal veins), and of the brachiocephalic trunk, necessitate suturing, and will be dealt with later. Descriptions of the operations on the other veins will be confined to the larger vessels, as the ligation of the smaller ones calls for no special description.

Ligation of the Internal Jugular Vein.—Gross reports forty-three cases of ligation of the internal jugular, with but four fatalities. The four patients died of secondary hemorrhage. Zaufal, in 1880, first brought to the attention of the profession the fact that sinus-phlebitis, treated by trephining the mastoid process and ligating the internal jugular vein when it is the seat of thrombosis, is, in a large percentage of cases, successful. In 1896 Hessler reported eighty-eight cases of sinus-phlebitis of the sigmoid fossa. In these cases the lateral sinus was evacuated seventy-six times and the internal jugular was ligated thirty-two times. Of this number, thirty-two terminated fatally. Macewen reported twenty-eight cases with but eight deaths; Rohrbach reported ninety-one cases with fourteen deaths, thirteen of which were due to infection (most of them occurring in preaseptic times). Only one death was attributable to circulatory changes, although nine cases had slight circulatory disturbances, such as lateral œdema of the face, headache, and loss of pupillary reflexes. Dangel reports three cases of death due to circulatory cerebral disturbances following unilateral ligation of the vein. In two of these cases death was caused by the presence of small anomalous internal jugular veins of the opposite side.

Operation.—The vein is exposed by an incision made along the anterior margin of the sternomastoid muscle as far down the neck as is necessary. It is, as a rule, ligated on a level with or just above the hyoid bone. The extent of the thrombosis or seat of injury definitely decides how low the vein should be ligated. The vein is located after the skin, the superficial fascia, and the platysma have been divided, and after the sternomastoid muscle has been retracted outward; it lies external to the carotid beneath the deep fascia.

Jones, in *The British Medical Journal* for 1906, interposes the following objections to the ligation of the internal jugular vein in otitic pyæmia: First, the other jugular vein may be small (anomalous), in which case the ligature would result in œdema of the brain. Second, a reverse current through the inferior petrosal and the posterior condyloid veins may occur, and in this way spreading of the infection may take place. Third, there is danger of wound-infection. As to the second objection, it may be stated that post-mortem examinations show that infection may take place along the same route even without ligation. The third objection loses much of its force when it is remembered that the tissues are usually already infected before the operation.

Ligation of the External Jugular Vein.—When this vein requires ligating, as the results of a wound or of infection, the condition is so obvious that a preconceived method of exposing it is not necessary. Ligature of this vein leads to no bad after-effects. (See the article on Surgical Diseases and Wounds of the Ear, in Vol. V.)

Ligation of the Innominate Vein.—Injuries of this vein that necessitate suturing or the application of a ligature, are no longer necessarily fatal. Stab-wounds of this vein have been sutured and the patient has recovered. Perfect results have also attended suturing of this vein after it has been injured during the removal of tumors. Goldman (*Lancet*, 1906, Vol. I., p. 82) reports two cases of successful ligation of the innominate vein—one on a patient affected with intrathoracic tuberculous goitre, and the other in a case of secondary epipleural abscess following costal caries. No circulatory disturbance followed either of these operations. Then the author goes on to say: "My most remarkable experience has been the following: A woman, thirty-four, suffered from chronic miliary tuberculosis. I traced its origin to a suppurating lymphatic gland, which had invaded the bulb of the jugular vein. In excising the gland copious hemorrhage resulted from a wound of the vein. Suture and lateral ligature were ineffective. Only after tying the common jugular, the subclavian, and innominate veins was I able to arrest the bleeding. Not the slightest circulatory trouble resulted. No abnormal veins were seen, and the circulation righted itself at once."

Brohl (*Centralblatt für Chirurgie*, 1896, p. 408) reports the following case: A woman, aged fifty-two, presented herself with a small tumor situated above the left clavicle. It was hard, of the size of a walnut, and presumably malignant in character, and it seemed to proceed from the left jugular vein. As a first step Brohl ligated the common jugular above the tumor, and on examining the latter he found that it was quite extensively in relation with the subclavian and innominate veins. He therefore sawed through the clavicle and ligated first the subclavian and then, after detaching the growth from its bed, the innominate. Then he drew the ends of the clavicle together and tamponed the wound. The tumor was found to be a melanosarcoma. No symptoms referable to the ligation occurred at or after the operation, not even œdema of the left arm; and four months afterward the patient presented only a slight enlargement of the superficial veins of the left half of the breast.

Kocher, in the last edition of his Operative Surgery ("Chirurgische Operationslehre," Jena, 1907, pp. 239 and 240), says that in those cases in which, during the progress of an intrathoracic surgical operation, it is not found possible to arrest the bleeding by a simple tamponade, the operator need not hesitate to apply ligatures to either the right or the left innominate vein, and also at the same time to the neighboring veins which pour their blood into it. It is understood, of course, that, in order to accomplish this, he will very often find it necessary, as a preliminary measure, to lift up temporarily the clavicle, to excise portions of the first and second ribs, or to make a lid-like opening through the manubrium sterni. He refers briefly to the successful cases of Jordan, Ricard, Brohl, Goldmann, Heinecke, Bardenheuer, and Plueckers, in most of which no unpleasant or alarming symptoms followed the closure of these large veins.

Ligation of the Subclavian Vein.—Ligation of this vessel should be resorted to only where the conditions are imperative. In injuries to this vein the hemorrhage should be controlled if possible by suture or by lateral ligation. After the vessel has been ligated the collateral circulation is readily established, provided that the circulation is otherwise normal and that no thrombus forms at the site of ligation. Injuries of this vein alone are uncommon, as the vein is protected by the clavicle. In gunshot and stab-wounds the artery and nerve are usually injured at the same time. Klemm reports a case of a stab-wound of the vein below the clavicle, with recovery after lateral ligation. According to Goldmann (*Beiträge zur klin. Chirurgie*, 1905, XLVII., p. 172), ligation of the subclavian vein has been practised with good results. He mentions the fact that gangrene did not follow in a single one of the four cases in which Choljzow ligated the subclavian vein. In two of the cases there was transient œdema of the corresponding arm, and in all there was a barely recognizable degree of cyanosis. In the case upon which he himself operated, the facts were as follows: A man, forty-four years of age, had extensive caries of the ribs on the right side. In the mammillary line there was a fistula that extended to the third rib. It was laid open, as was also a large tuberculous retro-mammary abscess that extended upward as far as the supraclavicular border. Portions of the second and third ribs were resected, and the lining membrane of the abscess was removed. In the course of this work a passage was found which led, below the clavicle, to the tubercle of Lisfranc on the first rib. The latter bone was found to be diseased throughout a distance of fully 4 cm. (one and one-half in.). In the course of the resection which the finding of this condition necessitated, the subclavian vein was wounded. It was therefore ligatured in two places, and divided between the ligatures. Closure of the wound, with drainage. No disturbance of the circulation in the arm followed the operation, and the external wound healed kindly. The patient was seen again at a much later date, and no evidences of any unfavorable result of the ligation could be discovered. In a case of double ligature of the subclavian vein reported by J. C. Warren, of Boston, considerable swelling of the arm followed the operation, but it soon subsided under maintenance of absolute rest, and the patient regained the entire use of the arm. A number of other instances might be cited from surgical literature, but these are sufficient. A noticeable feature in all of these reports is the absence of any mention of gangrene, of air embolism, or of the development of sepsis following the thrombosis of the vein. Modern aseptic and antiseptic technique is doubtless to be credited with these favorable results.

Ligation of the Axillary Vein..—Injuries of this vein are much less frequent than are injuries to the artery. Veins are injured usually as a result of operative procedures, such as the removal of diseased axillary lymph nodes, especially when the vein is embedded among them. The vein may also become the seat of thrombosis as a result of contusions produced by operations, fractures, dislocations, and wounds.

When the vein is injured below the entrance of the cephalic, ligation is a comparatively harmless procedure, the only result being a slight stasis in the arm, which disappears spontaneously or after elevation and bandaging of the extremity; but, when the injury is located higher up, ligation is a more serious matter, as the collateral circulation is insufficient. The vein is exposed through the same incision as that which is used for exposing the artery; the vein is found in front of the artery.

The published records contain many instances of the successful ligation of the axillary vein. One of the most recent is that reported by Richard R. Smith, of Grand Rapids, Mich. (*Annals of Surgery*, Vol. XXXIX., 1904, p. 757). In this case there was made accidentally, in the course of an operation for the removal of a cancerous breast, a transverse cut in the axillary vein. In length this cut involved about one-third of the circumference of the vein. A catgut ligature, completely occluding the lumen, was at once placed above and below the defect, and the operation on the breast was continued. No circulatory disturbance of any kind was afterward noted, and reports of a similar character are made by practically all the surgeons who have published their experience with regard to the operation of ligaturing the axillary vein. Similar results have followed ligature in two instances practised by Bryant.

Ligation of the Brachial Vein.—This calls for no particular comment. The indications for the ligation of this vein are the same as those which call for ligation of veins in general, and the vein may be exposed through the same incisions as those which are used for exposing the brachial artery. (See page 500.)

Ligation of the Inferior Vena Cava.—Lejars reports six cases of ligation of this vein, with four recoveries. Jacobsthal, in 1905, collected three cases of ligation of this vein. The first was performed by Schede, in 1888, the second by Manteufel, and the third by Garre. Houzel reports a case of ligation of this vein just below the renal. In this case it was found, after the lapse of four years, that perfect accommodation of circulation had taken place. Cumston reports cases operated on by Luecke, Bottini, and Heresco, with three recoveries. In two cases the vein was ligated just below the renal. Cumston observes that in these three cases there was either a tumor or a pus pocket pressing on the inferior vena cava, so that the collateral circulation was already somewhat developed before the operation was performed. Ligation of the vena cava above the level of the renal veins is not permissible, by reason of the fact that it invariably results in death; in injuries to the vein in this situation, such as are caused during operations, the wound should be sutured.

Ligation of the Superior Vena Cava.—So far as I am able to learn, this vein has never been successfully ligated.

Ligation of the Femoral Vein (below Poupart's ligament).—The old teaching was that ligation of this vein was apt to be followed by gangrene of the leg, as an adequate anastomosis was supposed to be more theoretical than real. The theory was that the valves prevented a backward flow of the blood into the venous system. Braun, however, has shown experimentally that these valves, in about eighty per cent of all experiments, give way under a pressure of from 145 to 160 mm. of mercury. This pressure corresponds to the arterial pressure. Verneuil, Karmisson, von Mass, von Bergmann, Braun, and Lossen soon proved clinically the correctness of this statement. Franz reports fifty-four cases of ligation of the femoral vein with but two instances of gangrene. One of these, that of Roux, was performed before the days of asepsis; the second case revealed, at the time of operation, the presence of a clot that extended into the common iliac vein, thus precluding the possibility of collateral circulation. In slight wounds of this vein complicated by severe hemorrhage and by weak heart action, suturing is to be preferred to ligation. If secondary hemorrhage follows suture or lateral ligation, double ligation is called for. Fear of air entering the vein and causing pulmonary embolism is unfounded. This occurs only in wounds near the heart. When the femoral artery as well as the femoral vein is ligated, the chances that an adequate collateral circulation will be established are much lessened, as the condition and position of the valves of the collateral veins hinder the free return of the blood to the heart. Braun has shown by experiment that the common femoral vein usually transmits all the blood to the abdomen. However, in the extirpation of tumors necessitating the ligation of this vein, no bad results follow. This is believed to be due to the fact that the pressure of the tumor causes the gradual establishment of the collateral circulation. Later observations and experiments have proved that the femoral vein can be ligated without producing gangrene even in the absence of tumors. The vein is exposed through the same incision as that used for exposing the artery. After the operation the limb should be suspended vertically so as to aid in overcoming the resistance exerted by the valves, especially those of the obturator and the circumflex iliac veins. Simultaneous ligation of the artery and vein results in gangrene in from forty to fifty per cent of all cases. In ligation of the artery and vein necessitated during the extirpation of tumors the chances of gangrene are somewhat lessened—viz., according to Kegeyama's statistics, to about thirty-nine per cent of all cases.

Ligation of the Internal Saphenous Vein.—Ligation of this vein is of particular importance because of the frequency with which it becomes varicose. A great many operations have been devised for the cure of varicosities of this vein, and, while many of them are followed by apparent cures, the results as a whole are not entirely satisfactory. In the majority of operations the veins ligated are superficial ones and multiple, and, although the ligation does away with the pressure of the blood column upon them, it acts in no way on the deep veins which in no small measure determine the development of superficial varicosities through their insufficiency and disease. Trendelenburg, in 1891, published the report of his method of controlling varicose veins of the lower extremities.

TRENDELENBURG'S OPERATION.—The saphenous vein is exposed by a longitudinal or by a transverse incision at the juncture of the upper and middle thirds of the thigh. The vein is ligated and divided between two ligatures, or, better yet, the ligatures may be placed sufficiently far apart to permit of the removal of about one inch of the vein. Many surgeons advocate ligating the vein just below its junction with the femoral, in order to avoid the possibilities of unusually high branching. Otherwise each branch would have to be ligated separately. In well-selected cases this operation affords prompt relief, and, while at first it is almost always satisfactory, it does not always establish a permanent cure, as recurrences not infrequently take place. The following list gives some idea of the amount of relief claimed for this operation:

Authority.	Cases.	Percentage of Apparent Cures.
Holtzmann	22	81.81
Perthes	87	78.05
Lenzner	98	56.
Harz	56	87.5
Ramsay	52	75.
Gaedeke	55	80.7
Tentschinski	21	67.

(The subject of varicose veins of the leg will be more extensively dealt with under the head of Surgical Diseases of the Heart and Blood-Vessels, in Vol. VI.)

V. VARIOUS OPERATIVE PROCEDURES UPON VEINS.

Lateral Ligation of Veins.—By lateral ligation of veins (Fig. 288) is meant the application of ligatures to the walls of veins for the purpose of closing wounds of these vessels without obliterating their lumens. This procedure has been advocated for the purpose of preserving the wounded veins of large size, such as the external jugular, subclavian, axillary, femoral, inferior vena cava, etc. The experiments performed by Mariotti ("La Chirurgia della Vena," 1906) prove that lateral ligature is useful in all those cases in which the wound does not exceed a few millimetres in length, be the wound parallel to the axis of the vessel or not. Wounds of seven or eight millimetres in length must be parallel to the axis of the vessel, as otherwise lateral ligature would involve a too considerable reduction of the lumen of the vessel. As a general rule, it may be stated that vessels tied in this manner must preserve at least one-half of their original calibre. The application of lateral ligature under other conditions renders the liability to secondary hemorrhage very great. This is due to the fact that the ligature is apt to slip in consequence of the traction exerted upon it by the venous walls. This accident is especially likely to happen in ligature of veins with very thick walls, such as the inferior vena cava. Transverse wounds of veins are especially suited to this form of ligature because of their tendency to gape widely.

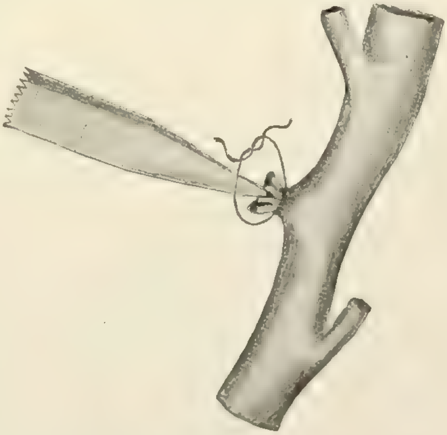


Fig. 288.—Lateral Ligation of a Vein; Ligature being Applied to Wounded Wall, which is held outward and puckered by means of forceps.

Operation.—First control the hemorrhage; then bring the vein well into the field of operation and seize its wounded lips with a single bite of a pair of dissecting forceps. Draw them outward from the walls of the vein in the form of a small cone, and tie the vein around the base of the cone with fine chromicized catgut or fine twisted silk. As the ligature is about to be tightened, tension upon the cone should be relaxed in order to throw the walls of the cone into folds. A reef knot is generally used. Many surgeons make a third loop of the ends of the ligature in order to prevent any untwisting of the ends of the knot through traction of the walls of the vein, and many prefer silk to catgut because there is less likelihood of its slipping or untying.

Braun reports the following cases of lateral ligature:

Veins.	Number of Cases.	Recoveries.	Deaths.
Internal jugular	12	9	3
External jugular	1	1	..
Subclavian	1	1	..
Axillary	5	5	..
Femoral	8	2	6

The three deaths following ligation of the internal jugular were due to secondary hemorrhage. Five of the six deaths following ligation of the femoral vein were due to pyæmia.

Temporary Ligation of Veins and Ligation of Veins en Masse.—These operations are practically the same as those described on page 528.

MINOR SURGERY.

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SURGICAL DRESSINGS.

The preparation and sterilization of the instruments, ligature and suture materials, textile fabrics, gloves, gowns, and other agents used in connection with surgical procedure; also the disinfection of the skin, as well as the general principles underlying the treatment of wounds, have already been considered in Vol. I. (p. 691). In the article on "Wounds of the Soft Parts," in Vol. II. (p. 605), suitable surgical dressings have been described. There remain, however, a few other surgical dressings of a general character which should be briefly described.

Dressings are used for preventing and overcoming infection, and they should be employed so as to contribute to the local and general comfort of the patient, securing rest and proper cleanliness of the parts involved.

Gauze.—Gauze forms an ideal dressing, the expense alone, especially in hospital use, interfering with prodigal outlay. However, gauze dressings once soiled may be washed, resterilized, and used again, but only on infected surfaces.

Oakum.—Oakum carefully fluffed and made into pads with gauze, then sterilized and bound in place, on infected suppurating surfaces, is a cheap and effective dressing.

Collodium.—Collodium, simple, flexible, or styptic, serves a valuable purpose in minor surgical matters. Slight incisions, limited abrasions, etc., of sterile character and in which bleeding has ceased, may be treated effectively with collodium alone or combined with sterile absorbent cotton or with gauze. In either instance the contiguous integument should be thoroughly cleansed, the wound carefully dried, and, perhaps, the borders approximated to each other before the agent is applied. The application is made by means of a camel's-hair pencil, the textile fabric being introduced from time to time as the putting on progresses. Several layers of either tissue (absorbent cotton or gauze) may be mingled with the collodium, and the area covered may thus be much extended. Iodoform and other medicaments are sometimes mixed with the collodium, but little if any advantage can be claimed for these combinations. The presence of fluid beneath this dressing is suggestive of present or impending infection and ought to prompt its quick removal, absorptive dressing being employed instead.

Adhesive Plaster.—Adhesive plaster, especially that in which zinc oxide is incorporated, can be utilized in place of collodium in the dressing of trivial wounds. The strips can be quite well sterilized by passing them, the adhesive side down, over the flame of a spirit lamp. But, before they are applied, the temperature of the reverse side should be tested, to obviate blistering the part. If the ends be turned under for a distance of a quarter of an inch or so, and the surfaces stuck together, the strips can be the more readily raised and with less annoyance to the patient than if the ends be directly applied to the skin. Adhesive plaster is also an admirable agent with which to confine dressings in place and to exercise pressure on, and control the circulation of, a part or the whole of a limb. When employed for these purposes it should be applied in accordance with the principles that regulate proper bandaging of the part, thus giving to the strapped and bandaged limbs similar appearances, especially as regards the spiral and imbricated arrangements of the dressings. Over discharging wounds, adhesive plaster may be applied in narrow strips, thus affording ample opportunity for the discharges to escape into the absorbent coverings that should be present in these cases.

Green-Silk and Rubber-Tissue Protective.—These are useful agents in dressing dry wounds of limited extent. But, when employed over extended surfaces, they interfere with evaporation and correspondingly macerate the tissues, and they thus facilitate the development of infecting agencies. When however, either of these agents is applied in the form of narrow strips, imbricated or not, as in skin-grafting (Fig. 289) and blood-clot organization (Schede), equitable temperature is maintained and free escape of discharges into superimposed absorbent dressings is promoted. Rubber tissue yields readily to the influence of overwarm or hot fluids and is often awkward to manage when in contact with either. Consequently it is of less practical use than the green silk.

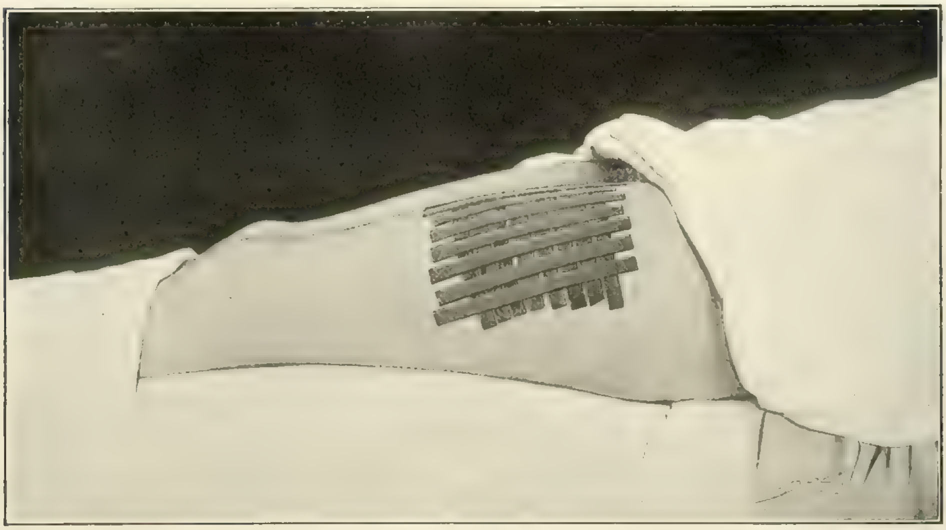

FIG. 289.—Green-Silk Protective Strapping for Skin Grafting and Raw Surfaces.

TAMPONADES AND DRAINS.

For vaginal tamponade, lamb's wool is employed; as a tampon for a wound, gauze is used. Drainage strips are of various widths, the edges being turned in and hemmed. A graduated tamponade, a pyramid built up of different-sized layers of gauze, is useful in exerting even pressure or in checking hemorrhage.

Umbrella Tampon.—This type of tampon (Fig. 290), formed by a rubber tube to which is sewed a curtain of gauze, is useful in bleeding from rectal and perineal wounds. The interior of the curtain is packed solidly with gauze strips after the tampon has been placed in the wound, the rubber tube allowing the escape of gas or urine, as the case may be.

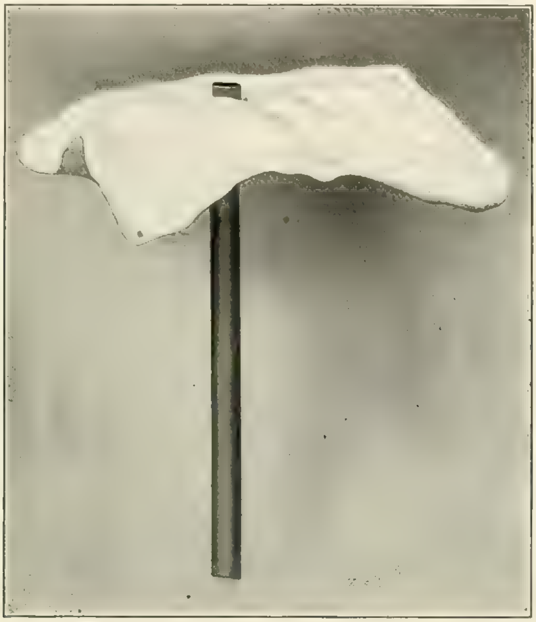

FIG. 290.—Umbrella Tampon for Perineal Section Wounds and Rectal Wounds.

FIG. 291.—Cigarette Drain.

Mikulicz Drain.—This is a bag of one or two layers of gauze into which, after being placed in the cavity to be drained, are packed strips of gauze.

Cigarette Drains.—A cigarette drain (Fig. 291) is made by enclosing a number of strands of lampwicking or several gauze strips, in a cover of green silk protective. The cover may be fenestrated or left plain. When this drain is employed in connection with serous surfaces it is better that the textile fabric part be not permitted to come directly in contact with them.

The three above-mentioned drains are useful in draining or packing large cavities and yet allowing of ready removal through a small opening.

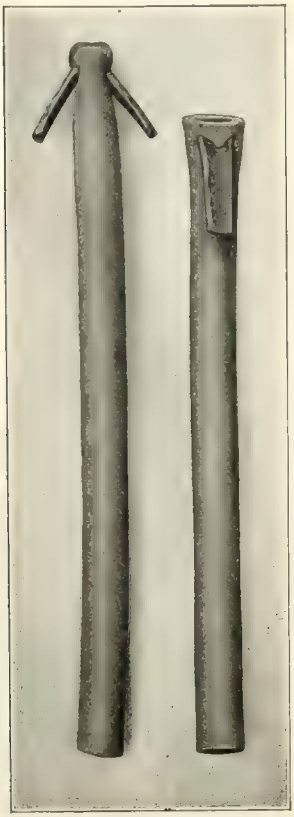

Fig. 292.

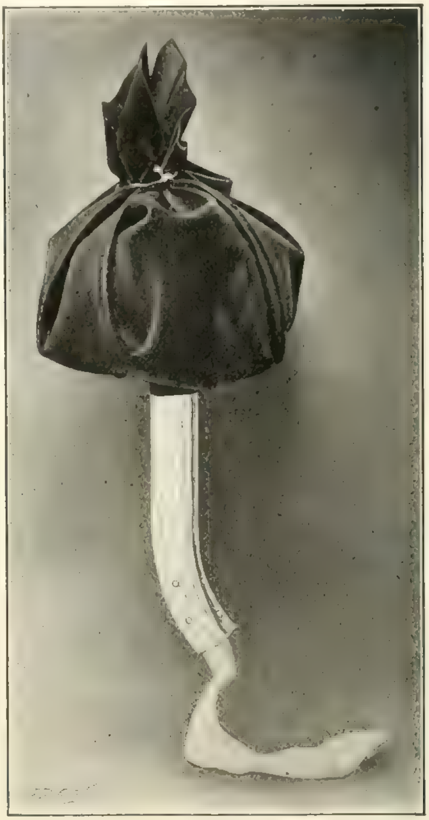

Fig. 293.

Fig. 292.—Harrison Method for Preparing Rubber Drainage Tubes.
Fig. 293.—Rubber Dam for Glass-Tube Drainage.

Other Forms of Drains.—Green-silk protective is useful as a capillary drain. Two or three strips should be used, and they should measure half an inch in width and several inches in length.

Rubber tissue is too readily disintegrated by wound secretions to act efficiently as a drain if prolonged drainage is required.

Rubber tubes are useful in various sizes and lengths. When used for draining an infected area, fenestræ should be placed only in the infected area. To fenestrate these tubes without reference to the sites of infection is promptly to invite infection throughout the entire area through which the tube passes.

A form of rubber tube useful in draining pelvic abscesses *per vaginam* has been devised by Harrison (Fig. 292).

Glass tubes serve the same purpose as rubber tubes, and in the majority of cases are better employed, for rubber tubes, after a certain length of time, prove irritating and increase the amount of discharge from the draining tract. The discharge through the tube may be kept from coming in contact with the wound by employing a bag of rubber tissue containing gauze, a strip of which leads down into the glass tube (Fig. 293).

BANDAGING.

Materials.—According to the specific purpose which they are to serve, bandages are made of various materials, those commonly employed being bleached and unbleached muslin, linen, crinoline, gauze, flannel, and rubber.

Uses.—Bandages are used for retaining dressings, as in the case of wounds; for retaining splints, as in fractures and dislocations; for making pressure, as in the palliative treatment of varicose veins and as in Bier's hyperæmia treatment of tuberculous joints and other infections, and for the arrest of hemorrhage; for purposes of immobilization, as in fractures, in which case a hardening agent such as plaster of Paris, paraffin, water-glass, or starch is worked into the bandage.

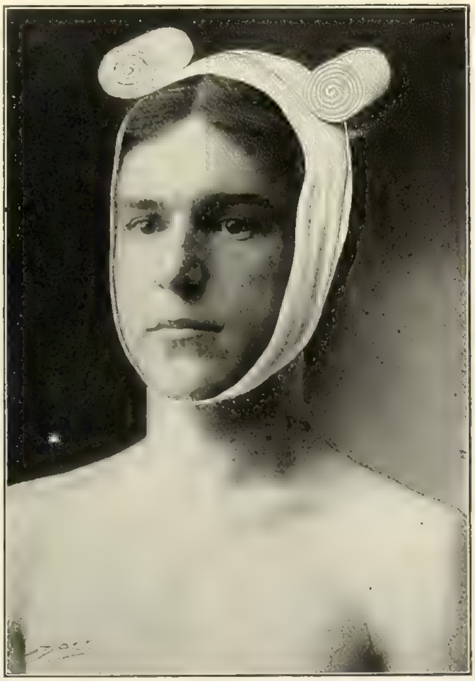

FIG. 294.—Double Roller Bandage of the Head.

Classification.—Bandages are classified according to the materials of which they are made, according to the form in which the material is made up, and according to the purpose for which the bandage is to be used. Bandages may be classified as follows:

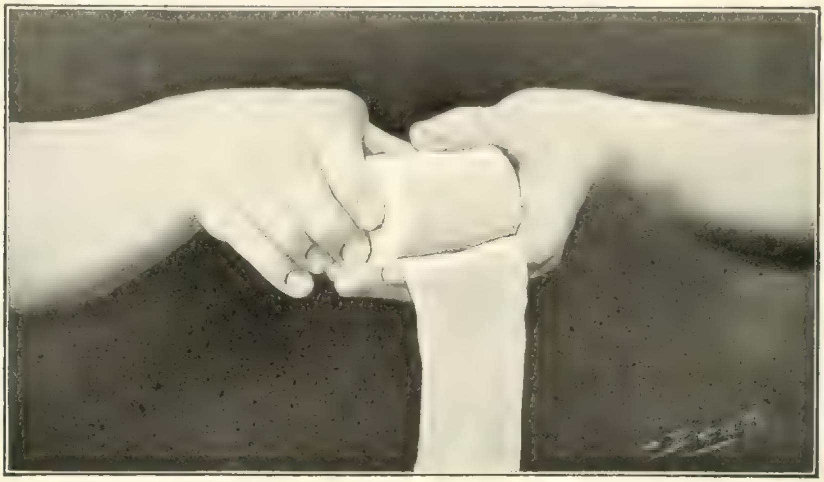

Fig. 295.—Rolling Bandage by Hand.

1. The simple or roller bandage, which may be a single or double roller (Fig. 294).

2. Compound bandages, or many-tailed bandages and slings.

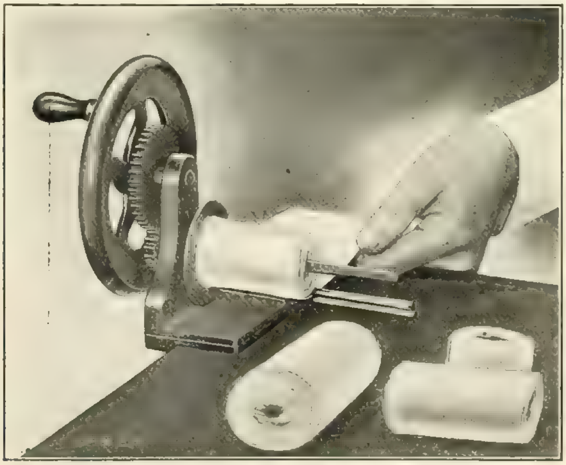

Fig. 296.—Machine for Rolling Bandages by Hand Power.

3. Immobilizing bandages, such as those made of crinoline or other large-meshed material in which plaster of Paris or starch or some other hardening agent has been incorporated. These are most frequently of the roller-bandage type.

4. Pressure bandages, usually made of rubber, such as Martin's rubber bandage.

Manufacture.—Of whatever material the bandage is composed the most frequently used is the roller bandage. These are made by cutting the selected material into strips that vary in width and length, according to the locality to be bandaged. If gauze is the material of which the bandage is to be made, a simple way of cutting the bandage straight, without frayed edges, is to draw a thread the desired length of the bandage, thus allowing of the clean cutting of the material along the line so marked. The strips are rolled into a cylinder either by hand or by means of a special machine. If they are rolled by hand, one end of the strip is first folded on itself a number of times until a smooth cylinder is formed. This cylinder is grasped by the right hand, the forefinger pressing upon one end, the thumb on the other, and while so held it is revolved by the fingers of the other hand in such a manner as to roll around it the rest of the strip which is guided by the left hand (Fig. 295); or, the bandage having been started in the above manner, the process may be continued by rolling it on a hard surface with the palm of the hand, or by placing the bandage on the anterior surface of the thigh and rolling it toward the knee with the palm of the hand. In either case tension should be made on the strip at the same time and care taken that with each revolution the strip accurately overlies the preceding one. Bandages may be rolled by a machine worked either by hand (Fig. 296) or by foot (Fig. 297). One end of the bandage is fastened under tension to the revolving spindle of the

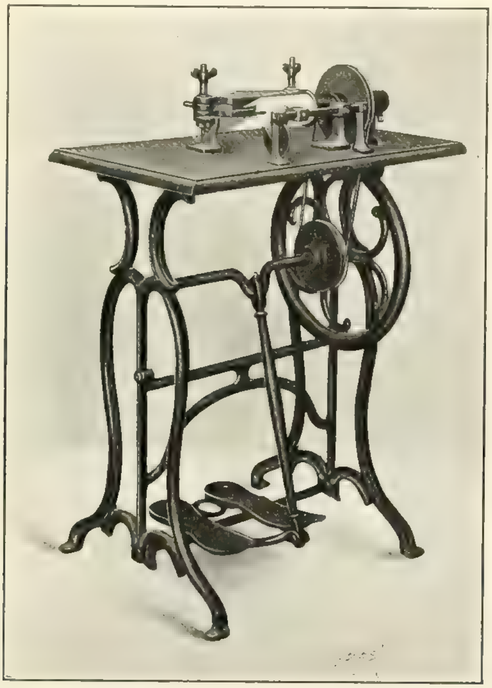

Fig. 297.—Machine for Rolling Bandages by Foot Power.

machine, and this, being turned by a crank, rapidly rolls up the strip. Bandages may be made rapidly in quantities in the following manner: A wide box, one foot deep, three feet wide, and long enough to accommodate the bolt of material, is required. This box (Fig. 298) is fitted with one-half dozen wooden rollers for guiding the material, and a metal roller with a crank attached, on which to wind the material. The required number of yards is wound on the metal roller and the material is cut across. The roll is removed by withdrawing the metal roller. This long roll is then cut into the required widths by means of a bandage knife. A Christy bread knife answers this purpose admirably. For steadying the roll while it is being cut a carpenter's small-sized mitre box is useful (Fig. 299).

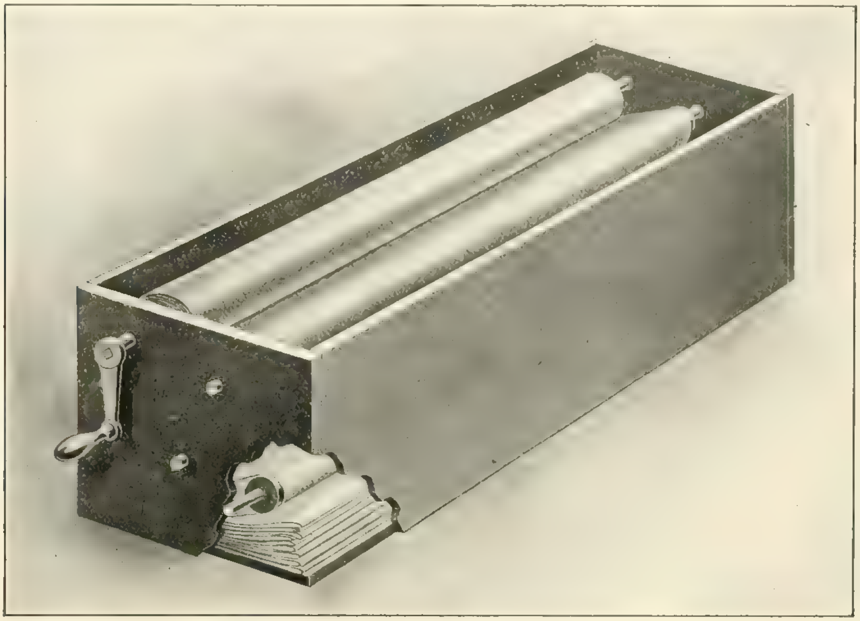

Fig. 298.—Apparatus for Rolling Large Bandages.

Dimensions.—The following are the most commonly used bandages, though other materials and other dimensions are used according to the part to which the bandage is to be applied, and also according to the purpose for which it is to be used:

Muslin, 7 yards long by $1\frac{3}{4}$, $2\frac{1}{2}$, 3, and 4 inches wide; gauze, 8 yards long, by 3 and $3\frac{1}{2}$ inches wide; flannel, 6 yards long by $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3, and 4 inches wide; crinoline, 6 yards long by 2, $2\frac{1}{2}$, $3\frac{1}{2}$, and 4 inches wide; finger bandages, 4 yards long by $\frac{1}{2}$ and $\frac{3}{4}$ inch wide; double roller head bandage, 10 yards long by $1\frac{1}{2}$ and 2 inches wide; chest or abdominal roller bandage, 10 yards long by 4, 6, and 8 inches wide; plaster bandages, 7 yards long by $2\frac{1}{2}$ and $3\frac{1}{2}$ inches wide; starch bandages, 1, 2, and 3 inches wide.

Certain terms are applied to different parts of the roller bandage in order to facilitate the description of its application. The free end is known as the initial extremity, the enclosed end as the terminal extremity, and all that portion between is termed the body of the bandage. The surfaces are known as internal and external.

General Rules.—In the application of the roller bandage the roller should be grasped tightly between the thumb and finger, the body of the bandage resting in the hollow of the hand, the loose end on the palm, so that it will unroll easily while resting in the palm. The internal surface becomes the external when it is applied to the part, and the external surface becomes internal. When a bandage is applied to an extremity, it should (when applied anteriorly) roll away from the median line of the body. The turns are always to be applied smoothly and with even pressure; otherwise, swelling or even gangrene may result. If it is too tightly applied, though with even pressure, ischæmic muscular paralysis may result. In the case of an extremity the bandage should be begun at the toes or fingers and applied in an upward direction. Before the application of

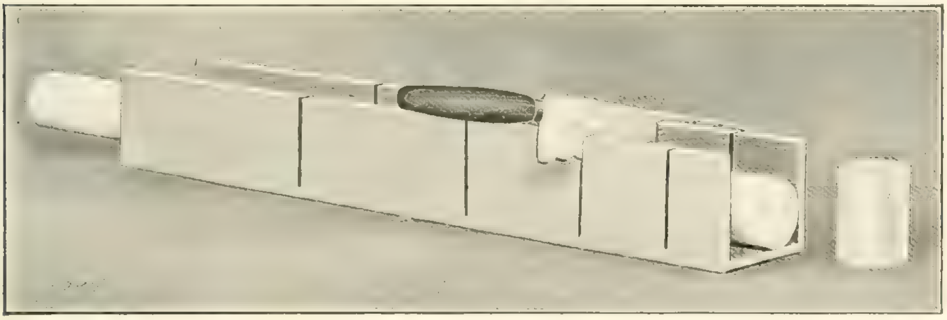

FIG. 299.—Mitre Box and Christy Knife for Cutting Bandages.

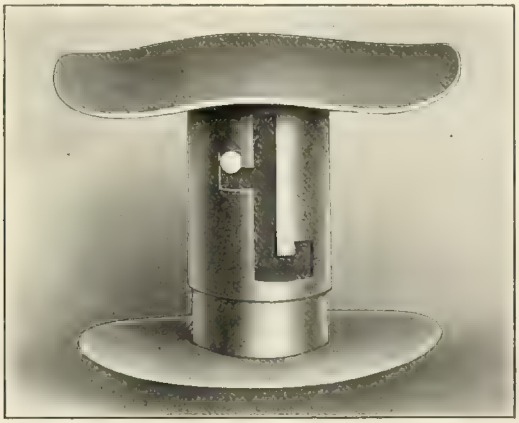

FIG. 300.—Volkmann Block.

the bandage the part to be bandaged should be placed in the position it is intended to retain after the bandage is applied. If this is not done the bandage will not lie smoothly and may subsequently cause uneven pressure. When bleached-muslin bandages are employed, the material may be wrung out of warm water, as this will be found to facilitate the applications, particularly in the case of small muslin bandages, such as finger bandages. The terminal extremity should be fastened, either by sewing with needle and thread or by the use of safety-pins, or the end may be torn longitudinally, knotted to prevent further tearing, and the two tails placed around the part in opposite directions and tied. When pelvic or chest bandages are applied, the patient being under the influence of an anæsthetic, the body may be supported by the Volkmann block (Fig. 300). An inverted hand basin serves the purpose in an emergency.

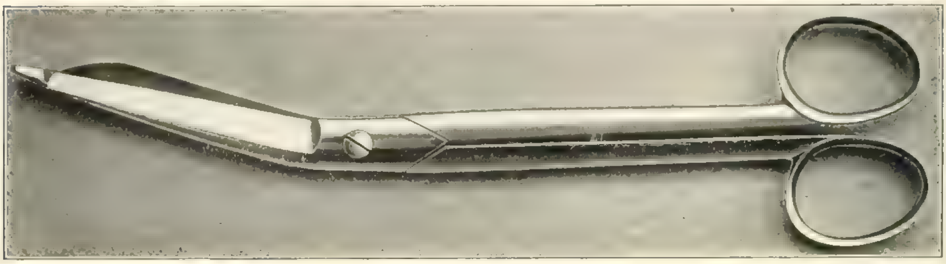

FIG. 301.—Bandage Scissors.

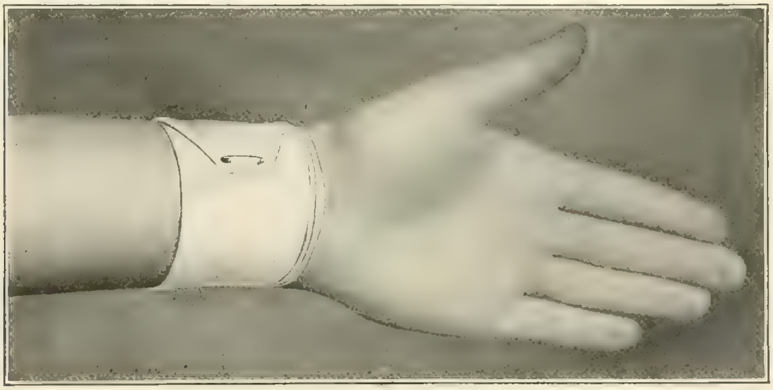

FIG. 302.—Circular Bandage of Wrist.

Bandages may be removed either by cutting or by unwinding them. If they are removed by cutting, special scissors having a blunt point on one blade should be used in order to prevent possible injury to the skin while cutting the bandage (Fig. 301). If a bandage is removed by unwinding it, the unrolled portion should be loosely grasped in the hands in a mass as the unwinding proceeds, and the unwound portion passed from one hand to the other, thus allowing of rapid and neat removal. In hospital practice bandages should be removed by unrolling rather than by cutting, unless they are too soiled to allow of ready cleansing, or unless their removal by unrolling would cause pain to the patient by undue moving of the affected part.

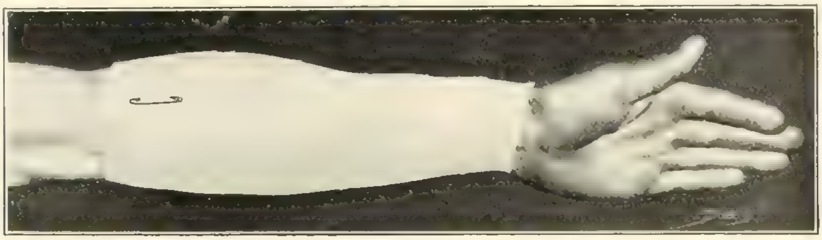

FIG. 303.—Spiral Bandage of Forearm.

Varieties of Roller Bandages.—In bandaging, a number of turns are used with which it is necessary to become familiar before applying any special bandage. Circular, spiral, and spica turns are used either alone or in combination, or with some modification, and the bandage the predominating feature of which is formed by these turns is known as a circular, spica, or spiral bandage.

Circular Bandage. — A circular bandage (Fig. 302) is made up of a number of circular turns, each turn accurately overlapping the turn preceding it. It is useful in retaining dressings upon circular portions of the body, as the head, upper arm, and neck, and for purposes of coaptation.

Oblique Bandage. — An oblique bandage is one in which the turns run obliquely around the part without overlapping. Such a bandage is useful in applying temporary dressings. The Esmarch bandage is applied in this manner, to allow of ready removal in the reverse order of that which was employed when it was originally applied.

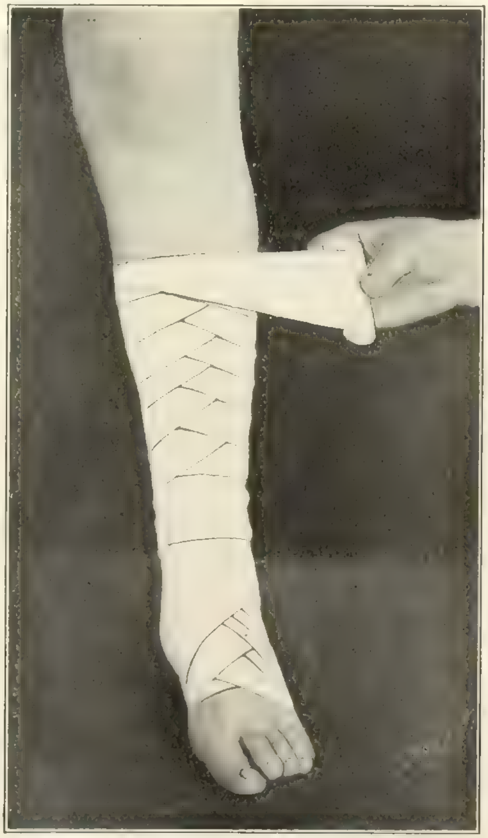

FIG. 304.—Spiral Reversed Bandage of the Leg, Showing the Method of Making the Reverses.

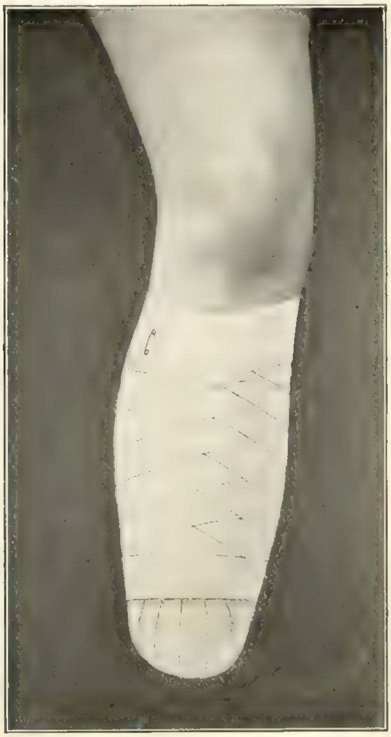

FIG. 305.—Recurrent Bandage of Stump.

Spiral Bandage.—In a spiral bandage (Fig. 303) the turns surround the part in a spiral manner, each turn covering one-half or more of the preceding turn. This form of bandage is useful in parts of the body which do not increase rapidly in circumference, as the finger, chest, or abdomen.

Reversed Spiral Bandage.—When the part of the body to be bandaged increases rapidly in circumference, as in the case of the forearm or leg of a well-nourished person, it is found impracticable to use spiral turns, as they do not lie smoothly and, what is more important, do not exert even pressure. To overcome this, when a part of the limb is reached where the spiral turn if continued would not lie smoothly, a "reverse" is made so as to cause the turn to conform to the shape of the part (Fig. 304). In making these reverses it is well not to unroll much of the bandage, but only six or eight inches of it. While the forefinger of the left hand presses on the previously applied turn and holds it in place, the head of the roller is turned toward the operator in such a manner that the slack is turned or folded obliquely on itself. As many of these reverse turns are applied as are required. Care must be taken that the points of the reverses are in alignment and that they are smoothly applied; also that they do not lie over bony prominences, such as the crest of the tibia, for here they may give rise to pressure effects.

Spica Bandage.—Spica turns are those which cross each other in the form of the capital Greek letter Lambda, and a bandage made up for the most part of these turns is known as a spica bandage (Fig. 322). Such a bandage is useful in

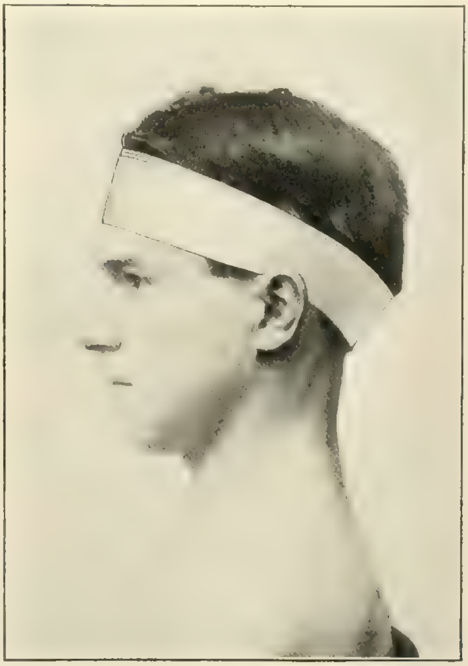

FIG. 306.—Fronto-occipital Bandage of the Head.

retaining dressings to the shoulder and groin, and also in exerting firm pressure.

Figure-of-8 Bandage.—These bandages (Fig. 320) are made of figure-of-8 turns, and are most frequently employed in the neighborhood of joints, a turn being first taken above the joint and then one below it, thus forming a figure-of-8. In the same manner a figure-of-8 may be applied to the leg, either short turns being used, when the bandage is known as a short figure-of-8, or longer ones with some spiral turns, when it is known as a long figure-of-8.

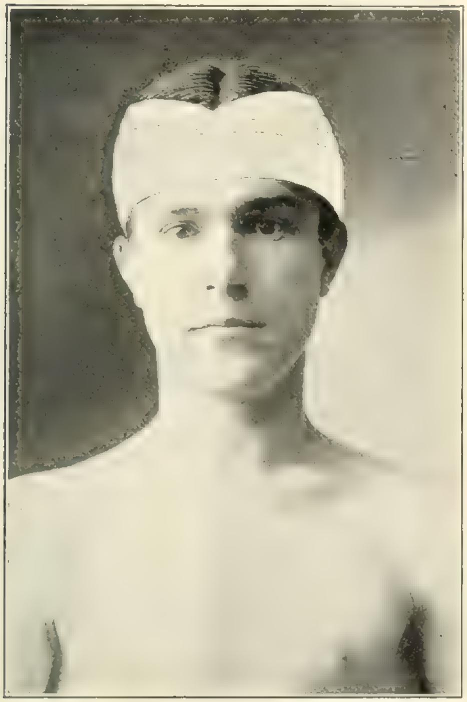

Fig. 307.—Oblique Bandage of the Head.

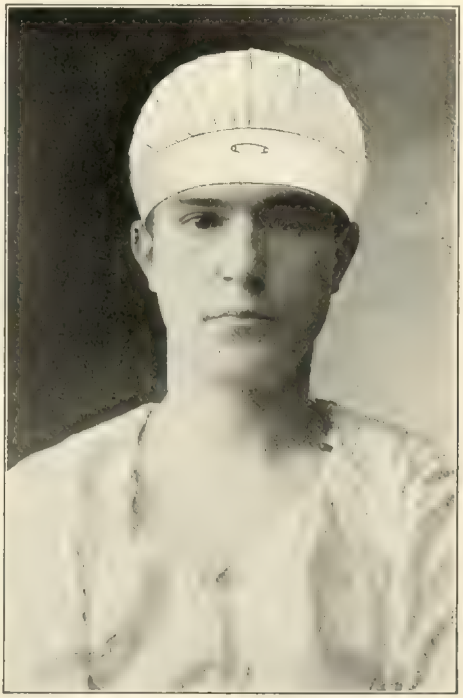

Fig. 308.—Recurrent Bandage of the Head.

Recurrent Bandage.—Recurrent bandages (Fig. 305) are made up of turns which extend back and forth over the part until it is covered in, all these turns being secured by spiral turns. This bandage is used for covering in the ends of fingers, for dressing stumps, and for retaining dressings upon the scalp.

Head Bandage; Fronto-occipital Bandage.—The initial extremity of the bandage (Fig. 306) is fixed beneath the inion by means of the index finger of the left hand; the roller is then carried across the parietal bone of the left side to the forehead, over the forehead, and over the right parietal region back to the starting-point; these turns are repeated, care being taken that each turn shall accurately cover the preceding turn. The terminal extremity of the bandage is fastened beneath the inion.

Oblique Bandage of the Head.—The initial extremity of this bandage (Fig.

307) is fixed by means of one or two fronto-occipital turns. From the occiput the roller is passed obliquely over the left parietal eminence to the forehead and then continued as in making a fronto-occipital turn that ends at the forehead. From the forehead the roller passes obliquely over the right parietal eminence to the occiput. At the occiput these turns are continued in the order named, each oblique turn covering in the lower two-thirds of the preceding oblique turn. The bandage is completed by one or more fronto-occipital turns, the terminal extremity being fastened beneath the inion. These oblique turns make a very pretty finish to a recurrent head bandage, and at the same time render it more secure.

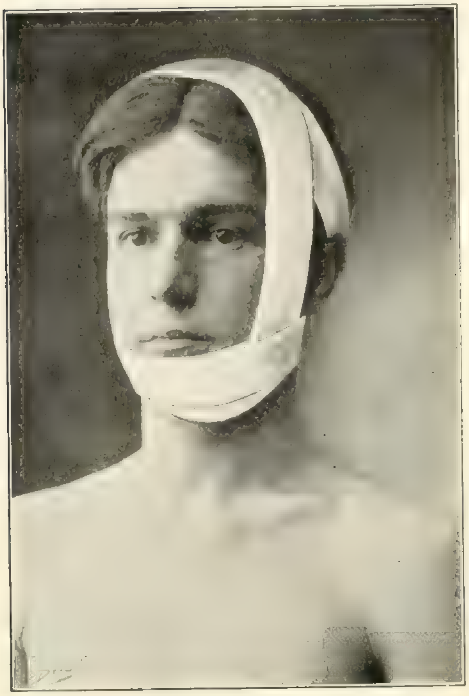
FIG. 309.—Barton's Bandage.

Recurrent Bandage of the Head.—The initial extremity of the bandage (Fig. 308) is secured by means of one or two fronto-occipital turns. Beginning at the central point of the forehead a reverse is made and the roller carried directly back to the median line over the vertex to just below the inion; here the roller is folded on itself and carried forward to the forehead, to the left of the first recurrent turn, so that it overlaps it by two-thirds. These recurrent turns are repeated between the occiput and the forehead until the whole of the left half of the vertex is covered. The recurrent turns are then secured by a fronto-occipital turn. In the same manner the right half of the vertex is covered in. The bandage is completed by one or more fronto-occipital turns.

Barton's Bandage.—The initial extremity of the bandage (Fig. 309) is fixed to the vertex of the head in the middle line, the index finger of the left

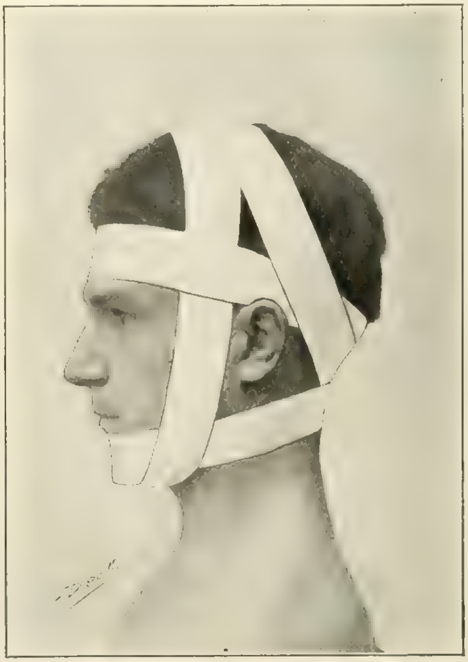
FIG. 310.—Modified Barton's Bandage.

hand being used for the purpose. The roller is then passed over the left parietal bone to a point below the inion, and then over the right parietal bone to the starting-point: this forms turn number 1. To form turn number 2, the roller is continued from the starting-point over the temporal bone, down the side of the left cheek, in front of the left ear, under the chin, up the side of the right cheek, in front of the right ear, and finally over the right temporal bone to the starting-point. To form turn number 3, continue from the starting-point over the left parietal bone to a point below the inion, below the right ear, around the right side of the inferior maxilla, to the front of the chin, passing over the anterior aspect of the chin to the left aspect of the inferior maxilla, and then over this and below the left ear to a point just below the inion. These three turns are repeated a number of times in the order described.

The bandage has been *modified* by adding (Fig. 310) a fourth turn—a fronto-occipital turn following the third turn. Except for this the modified Barton's is the same as the Barton's usually described. The points of intersection of the various turns are secured by safety-pins. In applying this bandage, as in applying all bandages which fix the lower jaw, care should be taken, when the application is made under an anæsthetic, that provision is allowed for the escape of vomited matter.

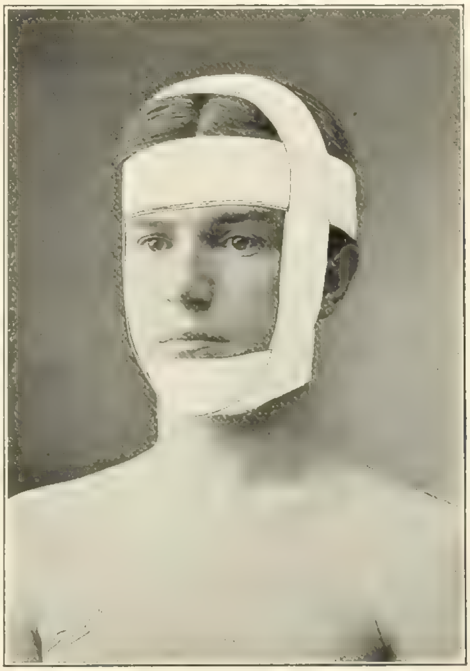

FIG. 311.—Gibson's Bandage.

Gibson's Bandage.—The initial extremity of the bandage (Fig. 311) is fixed with the forefinger of the left hand over the temporal region, just anterior to the left ear; thence the roller is carried down the cheek, under the chin, up in front of the right ear, and over the vertex to its starting-point. Three such complete turns are made. A reverse is made at the end of the third turn and the roller is carried to the inion, and three complete fronto-occipital turns ending at the inion are made. The roller is then carried around under the right ear, along the jaw to the chin, over the front of the chin, along the left side of the jaw, and under the left ear to the inion. Three such complete turns ending at the inion are made. Here the roller is reversed and carried in the median line from the vertex to the forehead, where it is fastened. All intersections of turns are secured by means of safety-pins.

A similar way of applying the turns, and one which perhaps is more secure, is to fix the initial extremity of the bandage at the vertex, and then to pass down the right side of the jaw in front of the ear to the chin, under the chin, up the left side of the jaw, in front of the ear, and so back to the vertex, where the initial extremity of the bandage is crossed by the roller, and the roller continued over the right parietal bone to the inion, under the inion, and up over the left parietal bone to the starting-point, thus making a figure-of-8 turn. This figure-of-8 turn is repeated three or four times, and then when the inion is again reached, on the third or fourth turn, the third turn of the Gibson bandage as before described is made.

Crossed Bandage of the Head.—A double-headed roller is used. A fronto-occipital turn is made, the bandage "crossing" just above the temporo-maxillary articulation (Fig. 312). The roller is carried down over the side of jaw, under the chin, and up the opposite side of the jaw to the temporo-maxillary articulation of that side. Here it is "crossed" by the other roller, which is passed over the vertex (Fig. 313). The points of "crossing" alternate.

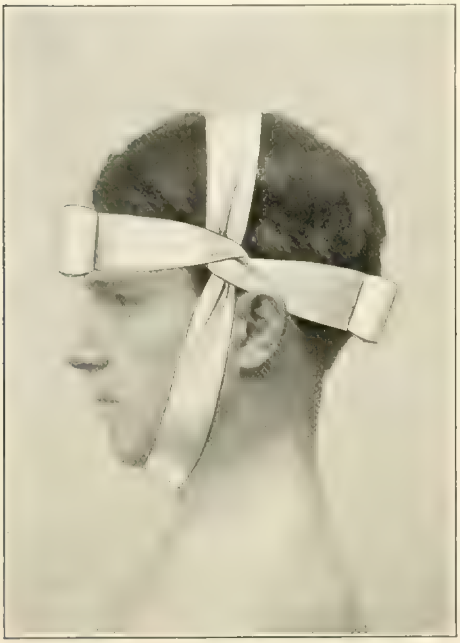

Fig. 312.

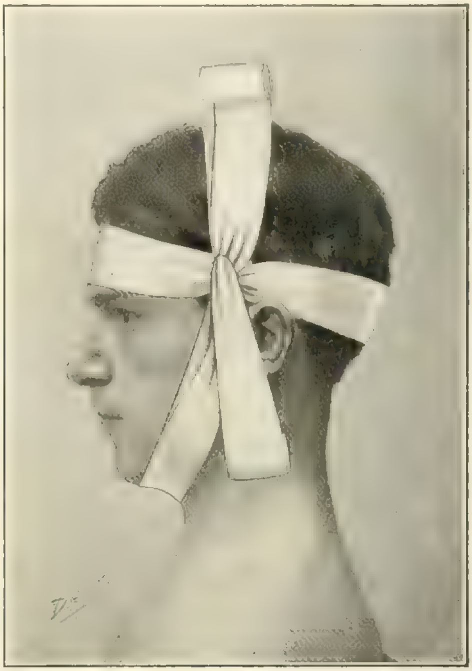

Fig. 313.

Fig. 312.—Crossed Bandage of the Head, First Turn.
Fig. 313.—Crossed Bandage of the Head, Second Turn.

Occipito-facial Bandage.—This bandage is applied in the same manner as the first and second turns of the Gibson bandage, by either of the methods just described. The turns along the side of the jaw, however, cover in more of the surface and do not accurately overlie each other.

Forehead and Chin Bandage.—The initial extremity of the bandage (Fig. 314) is fixed by one or two fronto-occipital turns. From below the inion the roller is passed around the side of the jaw, below the ear to the chin, across the anterior surface of the chin, and along the left side of the jaw, below the left ear, to a point below the inion. A fronto-occipital turn is then made. These turns are alternated.

The Forehead and Upper-Lip Bandage.—This bandage (Fig. 315) is applied in the same manner, except that the second turn passes from the inion to a point above the ear, thence to the upper lip, and so around above the opposite ear to the inion.

In the Forehead and Neck Bandage the second turn passes from the inion, around the neck, and back to the inion.

Oblique Bandage of the Jaw.—The initial extremity of this bandage (Fig. 316) is fixed by means of one or more fronto-occipital turns. If it is intended to cover in the left side of the jaw the roller is passed from right to left; if the right side, from left to right. From the occiput the roller is passed below the ear, under the chin, and up over the opposite angle of the jaw. It is then carried to the vertex from the side of the face just posterior to the external angular process of the frontal bone, and in front of the ear of the same side. The roller is carried across the vertex, behind the ear of the opposite side, to the point at which it first passed under the chin; thence it is continued around under the chin as before, this time, however, the turn being so placed as to overlap the posterior two-thirds of the previous turns. These turns are continued, each overlapping the posterior two-thirds of the previous turns until the space between the external angular process and the ear

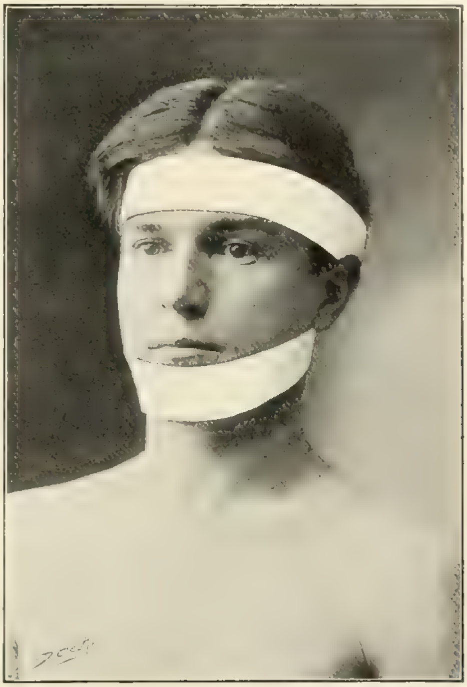

FIG. 314.—Forehead and Chin Bandage.

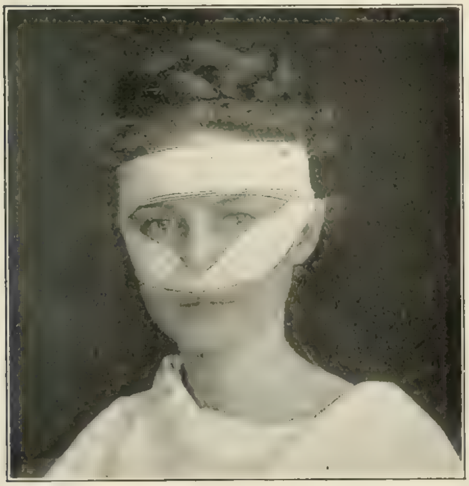

FIG. 315.—Forehead and Upper-Lip Bandage.

is completely covered. The oblique turns may include the ear if the indication for this is present. When a sufficient number of these turns have been applied, a reverse is made above the opposite ear, two or three fronto-occipital turns are made, and the bandage is secured.

Single-Eye Bandage.—The initial extremity of the bandage (Fig. 317) is fixed by one or two fronto-occipital turns. If it is desired to cover in the left eye the turns should pass from right to left; if the right eye, *vice versa.* From the occiput the roller is passed below the lobe of the ear to the cheek, upward over the cheek to the glabella, thence obliquely over the frontal and parietal regions of the opposite side to the occiput, forming turn number one; a fronto-occipital turn is then made. Turn number two is the same as turn number one, save that it ascends above it by one-third its width. It will be found more comfortable for the patient if the second and subsequent turns cover in the ear instead of passing below it, as in the case of the first turn. These turns are repeated, alternating with the fronto-occipital turns, until the eye is entirely covered in. A few fronto-occipital turns complete the bandage.

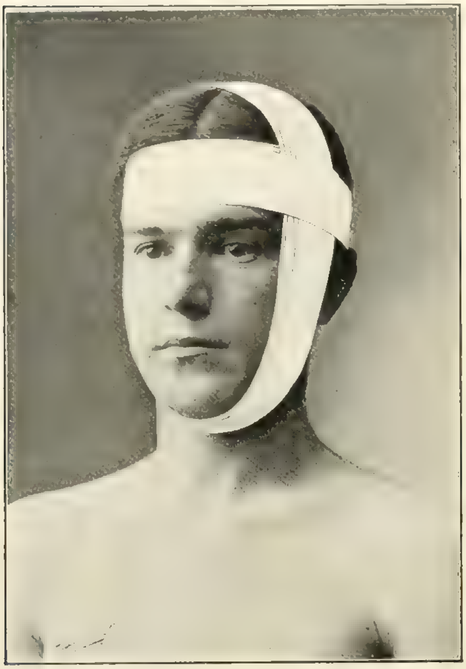

FIG. 316.—Oblique Bandage of the Jaw.

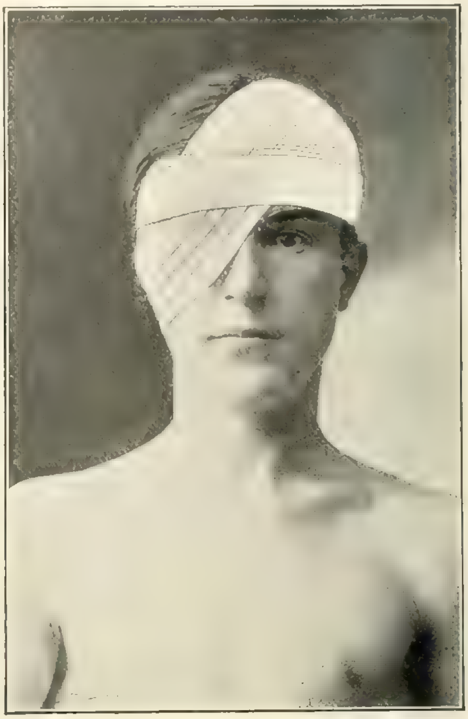

FIG. 317.—Single-Eye Bandage.

Bandage for Both Eyes.—The initial extremity of the bandage (Fig. 318) is fixed by one or more fronto-occipital turns. From the occiput the roller is passed under the lobe of one ear to the cheek, upward upon the cheek to the glabella, covering in the first eye, and thence obliquely across the opposite frontal and parietal regions to the occiput. A fronto-occipital turn is then made. From the occiput the roller is passed up over the parietal and frontal regions to the glabella, thence, over the second eye, obliquely down the cheek, beneath the lobe of the ear, to the occiput. Again a fronto-occipital turn is made. These turns are repeated first over one eye and then over the other eye, each succeeding turn covering in two-thirds of the preceding turn, and being alternated by a fronto-occipital turn. These turns are continued until the eyes are completely covered. The fronto-occipital turn may be omitted. (Fig. 319.)

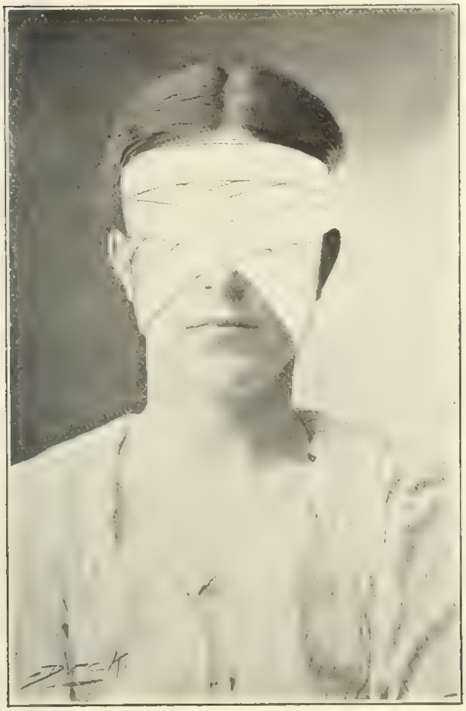

Fig. 318.

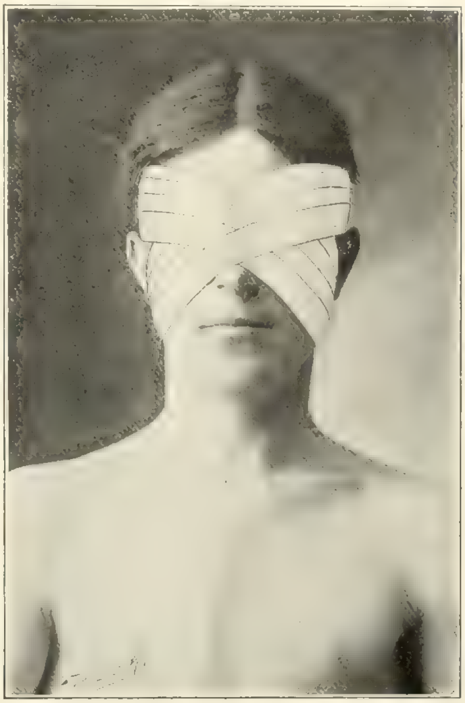

Fig. 319.

Fig. 318.—Double-Eye Bandage.
Fig. 319.—Double-Eye Bandage with Fronto-occipital Turns Omitted.

Figure-of-8 Bandage of the Neck and Axilla.—The initial extremity of the bandage (Fig. 320) is fixed by one or more circular turns around the neck; these should not be too tightly applied. According to the axilla to be included, the roller is passed obliquely across the corresponding shoulder, under the axilla, and back again obliquely over the same shoulder, crossing the first oblique turn. A circular turn is then made around the neck. The circular neck turns are alternated with the turns passing under the axilla and crossing over the shoulder. Each succeeding turn overlaps the preceding one by two-thirds of its width. A circular turn around the neck completes the bandage.

Combined Neck Bandage.—A combination of head, neck, and chest turns is useful in securely retaining the dressing after an extensive dissection in the cervical region. (Fig. 321.)

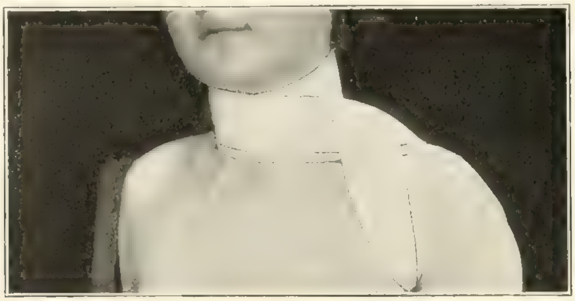

Fig. 320.—Figure-of-8 Bandage of Neck and Axilla.

Ascending Spica Bandage of the Shoulder.—The initial extremity of the roller (Fig. 322) is fixed by means of one or two circular turns around the arm of the affected side at the level of the axillary fold, or a short distance below it. The roller is carried directly across the anterior aspect of the chest to the axilla of the opposite side, under the axilla to the posterior aspect of the chest, and finally across this to the starting-point. A circular turn is next made around the arm at the starting-point, and then a second turn, similar to the first, but ascending and covering in two-thirds of the previous turn, is made around the chest. Except at the opposite axilla, where the turns exactly overlap each other, the chest turns are alternated with the circular turns around the arm, each succeeding turn ascending by one-third of its width above the preceding turn. In this manner the shoulder is ascended by spica turns until it is completely covered. The bandage is completed by a circular turn around the arm and there fastened. To prevent chafing of the opposite axilla, a pad of cotton should be held in place there by the first turn of the bandage around the chest.

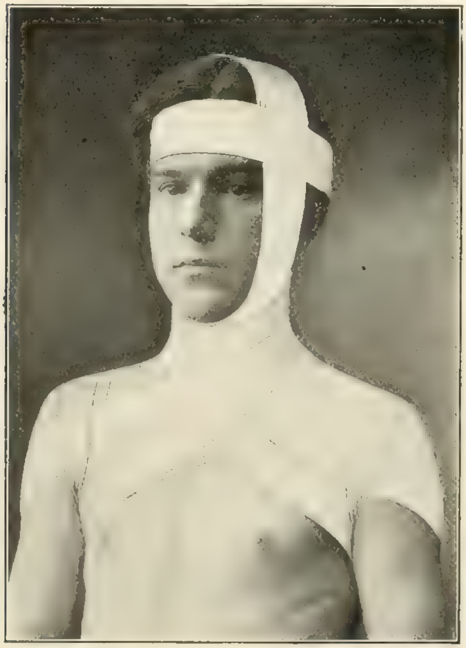

Fig. 321.—Combined Head, Neck, and Shoulder Bandage.

Descending Spica Bandage of the Shoulder.—The initial extremity of the bandage (Fig. 323) is secured by means of one or two circular turns around the arm at the level of the axillary fold or a short distance below it. The roller is carried over the shoulder to the anterior aspect of the chest as high up as it can be made to stay, then under the axilla of the opposite side, around the posterior aspect of the chest, to the starting-point, where a circular turn is taken. These turns alternate one with another, each chest turn descending by one-third the width of the preceding turn until the shoulder is completely covered in. The bandage is finally completed by a circular turn around the arm. The same precautions are taken, as regards the opposite axilla, as in the case of the ascending spica of the shoulder.

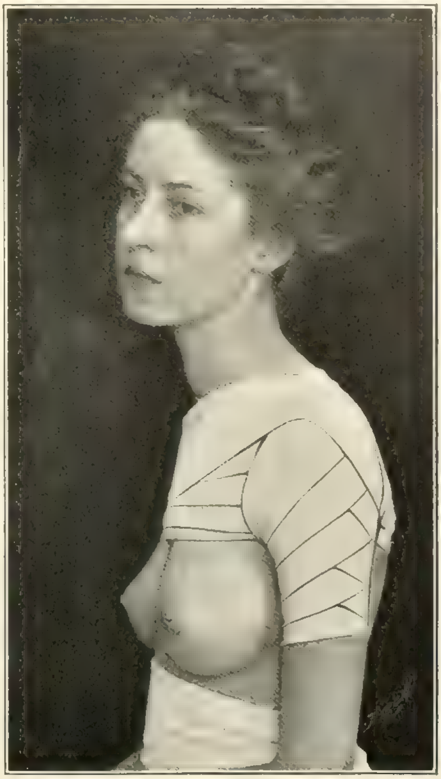
Fig. 322.—Ascending Spica of the Shoulder.

Velpeau Bandage.—Two or more roller bandages are required. The arm of the affected side is drawn across the chest, the palmar surface of the fingers resting upon the sound shoulder near the base of the neck. The initial extremity of the roller is placed over the scapular region of the unaffected side, and the roller is carried over the point of the affected shoulder; thence it is carried down across first the outer and then the posterior surface of the arm of the same side, and under the elbow to the anterior chest wall, from which point it should pass diagonally across the anterior chest wall upward to the axilla of the unaffected side, and under the axilla to the starting-point, thus completing the first turn. (Fig. 324.) This turn is repeated in order firmly to fix the initial extremity of the

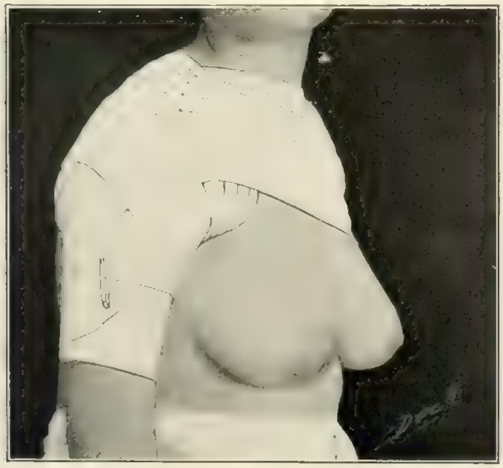
Fig. 323.—Descending Spica Bandage of the Shoulder.

roller. From the scapular region the roller is carried directly around the body, passing over the elbow of the affected side near its point, thence to the axilla of the sound side, and thence to the starting-point, over the scapular region of the sound side. (Fig. 325.) These turns alternate one with another, each succeeding turn overlapping the preceding one by two-thirds its width, and the shoulder turns gradually approaching the base of the neck; the turns cross the elbow and gradually ascend the arm until the last turn passes across the wrist and is secured in the axillary line of the sound side. (Fig. 326.) In applying this bandage, as in other cases in which skin surfaces are pressed to-

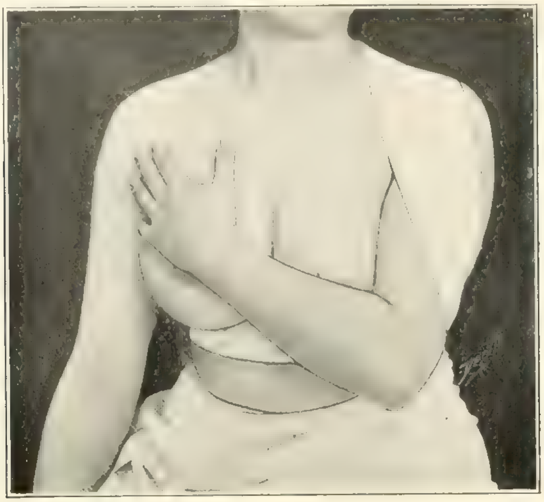

Fig. 324.—Velpeau Bandage, First Turn.

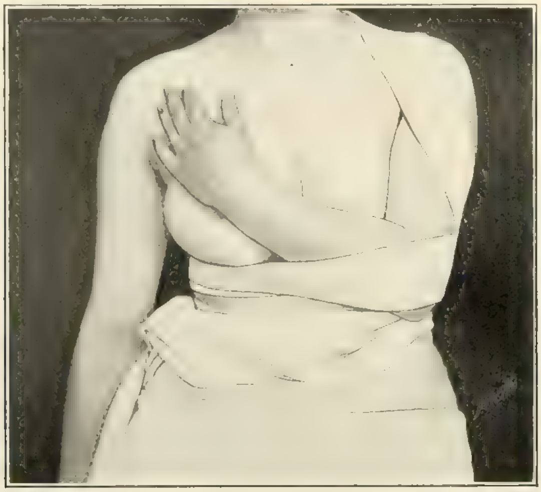

Fig. 325.—Velpeau Bandage, Second Turn.

gether, a layer of cotton should be placed between such surfaces and plenty of drying powder be used to prevent maceration and excoriation.

The Desault Bandage consists of three roller bandages. A wedge-shaped pad is placed in the axilla of the injured side. This is held in place by the first roller of the bandage. The initial extremity of the bandage is held in place by pressure of the fingers of the left hand over the lower ribs of the injured side; the bandage itself is then carried obliquely across the anterior aspect of the chest, over the shoulder of the sound side, and thence through the axilla to the apex of the shoulder, when it crosses the first turn. Then it passes diagonally across the back to the injured side, fixing the initial extremity by passing over it low down on the ribs. The chest is then ascended by spiral turns which thus securely fasten the wedge-shaped pad in position. These spiral turns ascend to the level of the axilla. The arm is now brought to the side, the pad acting as a fulcrum. The second roller of the Desault is a series of ascending spiral turns including the arm and chest. These turns begin just above the elbow of the injured side, and end just below the level of the shoulder.

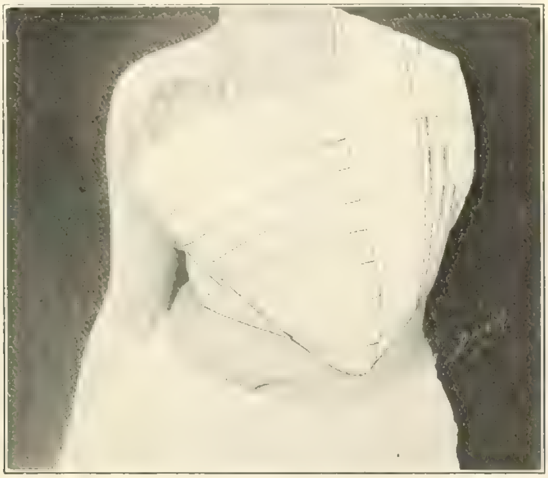

FIG. 326.—Velpeau Bandage, Completed.

The initial extremity of the third roller is fixed in the axilla of the sound side by the fingers of the left hand, and the roller is carried obliquely across the chest to and over the shoulder of the injured side, directly downward to the elbow of the injured side, over this and diagonally up across the chest to the starting-point; thence the roller is carried obliquely over the posterior aspect of the chest to and over the shoulder of the affected side directly down to and over the elbow of the affected side. Thence it passes diagonally across the posterior aspect of the chest to the starting-point. These turns are repeated until the roller is finished. The hand is supported by a bandage sling.

The Desault bandage is used in fractures of the clavicle, the pad being the fulcrum over which the second roller forces the arm to the side in such a manner as to correct the inward displacement of the fracture of the clavicle. The third roller, by elevating the shoulder, corrects the downward and forward displacement.

Figure-of-8 Bandage of the Elbow.—The bandage (Fig. 327) should be applied with the arm flexed. The initial extremity of the bandage is fixed by one or more circular turns made a few inches below the elbow joint. The roller is then carried across the flexure of the joint and a circular turn is made a few inches above the joint. The roller is then carried obliquely to the starting-point and a circular turn is made there. Circular turns below the joint alternate with those above the joint, the bandage each time obliquely crossing the flexure of the elbow. The circular turns gradually approach the tip of the olecranon from both directions. The bandage is finally completed by a circular turn around the flexure, thus covering in the olecranon. A neater effect may be produced by first passing a circular turn around the flexure of the joint and over the tip of the olecranon then a circular turn below, and then one above, and so on until the joint is completely covered, each turn covering in two-thirds of the preceding one.

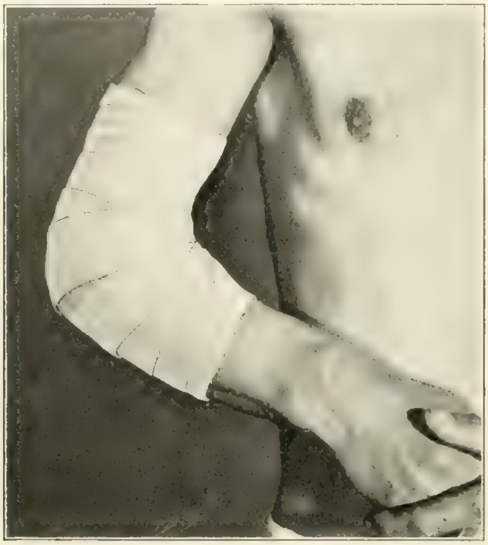

Fig. 327.—Figure-of-8 Bandage of the Elbow.

Reversed Spiral Bandage of the Upper Extremity.—The initial extremity of the bandage (Fig. 328) is fixed by means of one or two circular turns around the wrist. The roller is then carried obliquely across the back of the hand to the level of the last phalangeal joint. Here a circular turn is made. By means of spiral or reverse spiral turns the roller ascends the hand to the metacarpo-phalangeal joint of the thumb, passes obliquely to the wrist, where a circular turn is taken around the wrist, thence back obliquely to take a circular turn around the body of the hand. Three or more of these figure-of-8 turns are made, thus carrying the bandage down as far as the wrist. The forearm is ascended by means of spiral or spiral reverse turns, according to the conformation of the forearm, until the elbow is reached. If it is desired to keep the arm flexed the elbow is covered by a series of figure-of-8 turns while the part is in a state of flexion. If, however, the arm is to be kept extended, spiral and spiral reverse turns are continued over the elbow and up the arm. The bandage is completed by one or two circular turns at the level of the axillary fold. Care should be taken in applying this bandage that the reverses do not press over bony prominences, as the ridge of the ulna, also that the reverses are in accurate alignment.

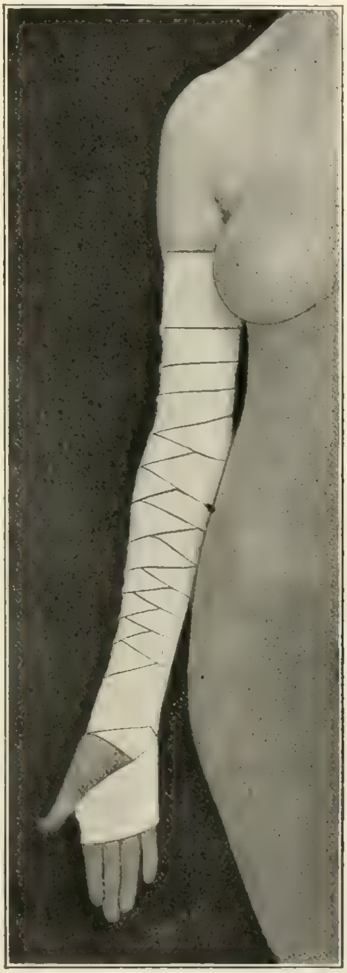
FIG. 328.—Reversed Spiral Bandage of the Upper Extremity.

Figure-of-8 Bandage of the Hand and Wrist (Dorsal).—The initial extremity of the bandage (Fig. 329) is fixed by one or two circular turns around the wrist. Thence the roller is carried obliquely across the dorsum of the hand to the base of the index finger, where a circular turn and a half is made around the hand at the metacarpo-phalangeal articulation. The roller then returns obliquely to the wrist. After a circular turn at the wrist has been completed the roller is again carried obliquely to the base of the index finger, and a second circular turn is made around the hand. These turns are continued, each overlapping the preceding turn by two-thirds of its width, until the dorsum of the hand is completely covered. A circular turn at the wrist completes the bandage.

Figure-of-8 Bandage of the Hand and Wrist (Palmar).—This is applied in the same manner as the dorsal figure-of-8 of the hand and wrist, except that the oblique turns cross the palm instead of the dorsum of the hand.

Demi-gauntlet Dorsal Bandage.—The initial extremity of the bandage (Fig. 330) is fixed at the wrist by one or two circular turns. The roller is carried obliquely across the back of the hand to the base of the thumb, which is surrounded by a circular turn, and the roller is returned to the wrist. Here a circular turn is made, and the roller is carried obliquely across the back of the hand to the base of the index finger, there making a circular turn and again returning to the wrist. This is continued until the base of each finger has in due order been surrounded by a circular turn. The bandage is completed by a few figure-of-8 turns of the hand and wrist.

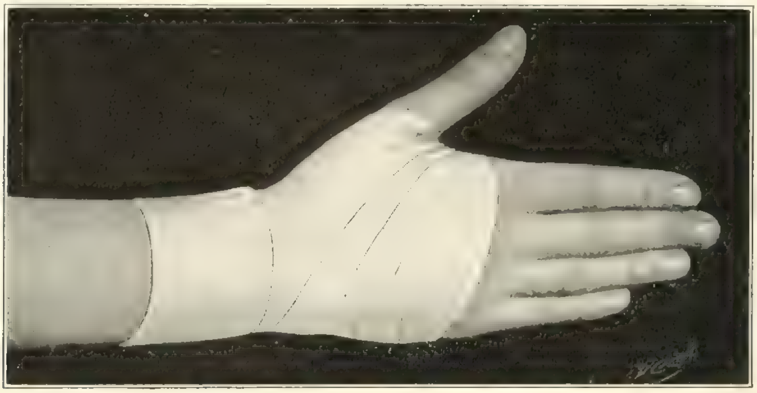

FIG. 329.—Figure-of-8 Bandage of the Hand and Wrist (Dorsal). In the drawing the turns of the bandage should have been carried farther down on the fingers.

Demi-gauntlet Palmar Bandage.—This bandage is applied in the same manner as the dorsal demi-gauntlet bandage, except that the oblique turns from

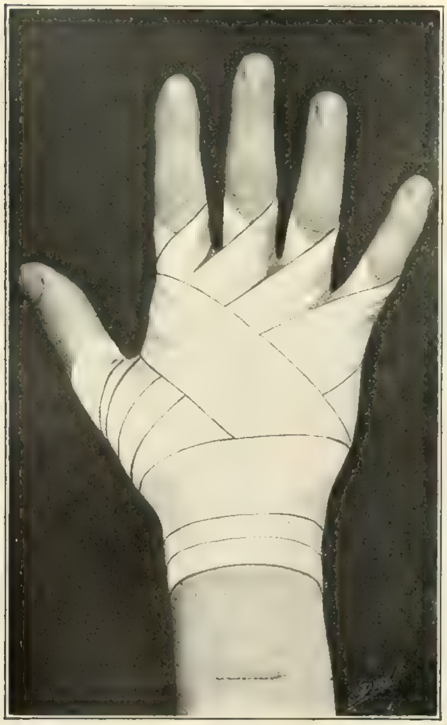

FIG. 330.—Demi-Gauntlet.

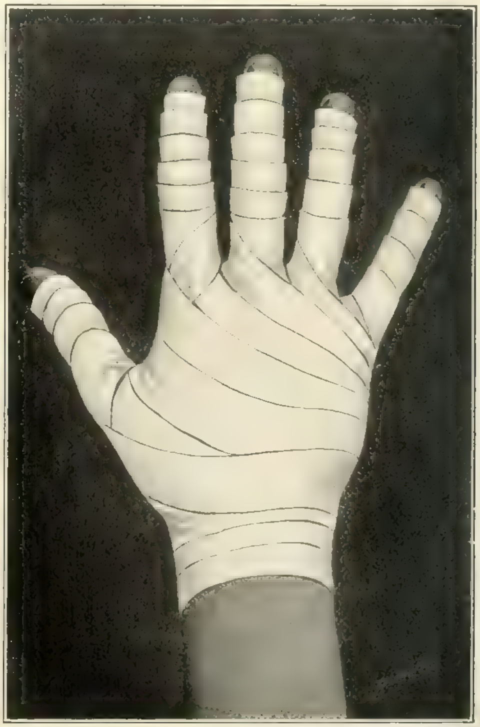

FIG. 331.—Gauntlet.

the wrist to the bases of the fingers pass over the palmar instead of the dorsal surfaces.

Gauntlet Bandage.—The initial extremity of the bandage (Fig. 331) is fixed by means of one or two circular turns at the wrist. The roller is then carried by an oblique turn to the tip of the thumb, and the thumb covered by spiral or spiral reverse turns. Upon the completion of these turns the roller is carried back to the wrist, a circular turn made there, thence to the index finger, which is bandaged in the same manner as the thumb. In like manner the remaining fingers are covered. The bandage is completed by a few circular turns at the wrist, or additional figure-of-8 turns may be passed around the hand and wrist for further security.

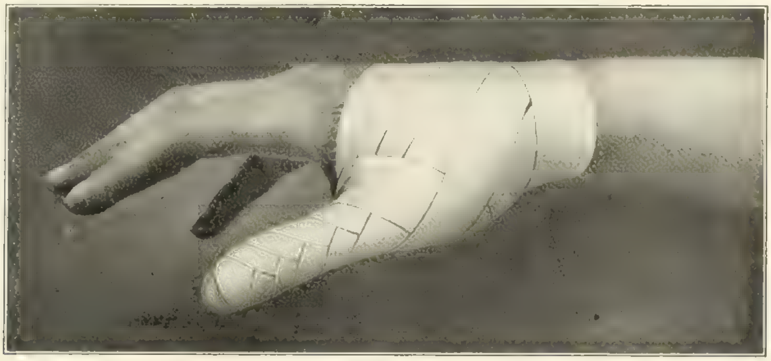

FIG. 332.—Spica Bandage of Thumb.

Spica Bandage of the Thumb.—The initial extremity of the bandage (Fig. 332) is fixed by one or two circular turns around the wrist. The roller is then carried over the dorsal aspect of the tip of the thumb and there a circular turn is made. The roller returns to the wrist and a circular turn is made around the wrist. Thence the roller is again carried obliquely across the dorsal aspect of the thumb. A second circular turn is made around the thumb, this last overlapping the first turn by two-thirds of its width. This procedure is continued until the thumb is covered, a turn around the wrist completing the bandage. A few recurrent turns may be first placed over the tip of the thumb if it is desired to include this in the bandage.

Spiral Bandage of the Finger.—The initial extremity of the bandage (Fig. 333) is fixed by two or three turns around the middle phalangeal joint. The bandage is then carried in a spiral manner to the base of the finger, each turn covering in one-half of the preceding turn. A circular turn is made at the base of the finger and the bandage is carried by means of spiral turns to its starting-point at the middle phalangeal joint. From the posterior surface of this joint a recurrent turn is now passed directly over the tip of the finger to the anterior surface of the joint, the fingers of the operator's left hand holding this turn taut while a

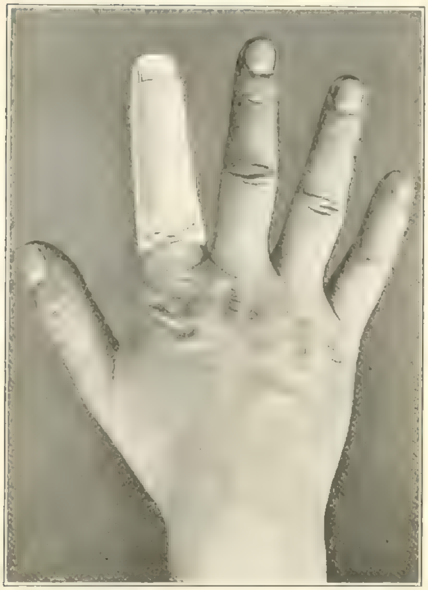

Fig. 333.—Spiral Bandage of the Finger, First Method. The extension to the wrist is omitted.

second recurrent turn is passed back over the inner half of the finger tip to the starting-point of the first recurrent turn. This is also held in place and a third and final recurrent turn is passed over the outer half of the finger tip. A circular turn secures the ends of these three recurrent turns. The bandage is then carried to the distal end of the finger by means of spiral turns. At the extremity a circular turn is taken that secures the recurrent turns which extend on either side of the finger tip. Finally, by means of spiral turns the base of the finger is reached and the bandage is fastened there by splitting it longitudinally for a distance of six or eight inches, then knotting it just beyond the split to prevent further splitting, and tying the ends directly around the base of the finger; or the bandage may be split for a distance of ten or twelve inches, the long ends being knotted and carried around the wrist once or twice and then tied securely. The last method effectually prevents the loosening or falling off of the bandage.

A Second Method of applying the spiral bandage to the finger is to fix the initial extremity of the bandage by taking two or three turns around the base of the finger. (Fig. 334.) From the posterior aspect of the base of the finger the bandage is passed directly over the finger tip to the anterior aspect of the base of the finger. The second and third recurrent turns are passed in like manner over the inner and outer half of the finger tip. A circular turn at the distal extremity holds these in place, following which a series of spiral turns descend to the base of the finger where the bandage is completed by a circular turn.

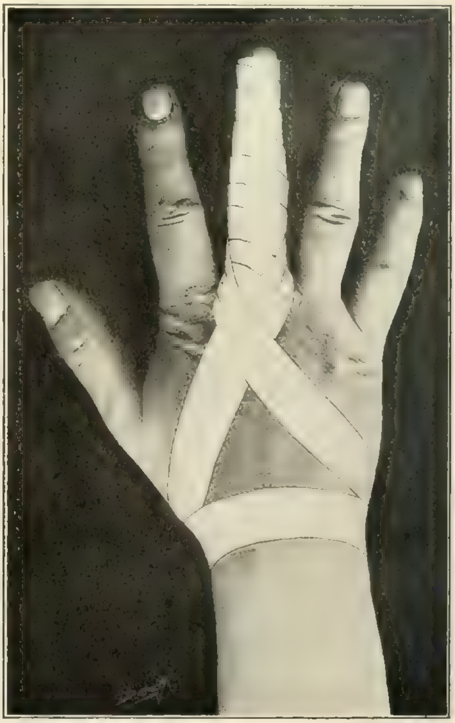

Fig. 334.—Spiral Bandage of Finger, Second Method.

A Simpler Method may be used where it is not desired to cover in the finger tip. The initial extremity of the roller is secured by two or three circular turns around the base of the finger, the finger is then ascended to its tip by spiral turns, a circular turn is made at the tip, and by means of spiral turns the base of the finger is again reached, where a circular turn completes the bandage.

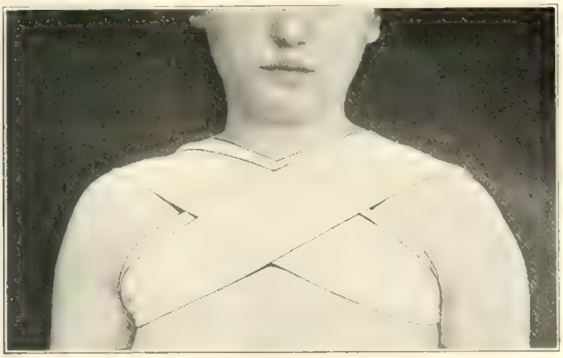
Fig. 335.—Anterior Figure of-8 Bandage of the Chest.

Reversed Spiral Bandage of the Finger.—This bandage is applied in the same manner as any of the spiral bandages just described, with the exception that reverse spiral turns are used in place of spiral turns.

Anterior Figure-of-8 Bandage of the Chest.—The initial extremity of the roller (Fig. 335) is fixed by means of the index finger of the left hand over the middle third of the sternum. The roller is then carried over one shoulder to its posterior aspect, under the axilla of the same side to the anterior aspect of the shoulder, diagonally across the chest to the posterior aspect of the other shoulder, under the axilla to the anterior aspect of the chest, and diagonally across to the starting-point, thus forming a cross over the sternum. These turns are repeated a number of times. The bandage may be *modified* by first making a few circular turns around the chest at the level of the axillary fold or by alternating these circular turns with the figure-of-8 turns. The turns may be placed in such a manner that each shall exactly cover in the preceding one, or each turn may overlap the preceding one by two-thirds of its width. The bandage is fastened by pinning through the intersections over the sternum.

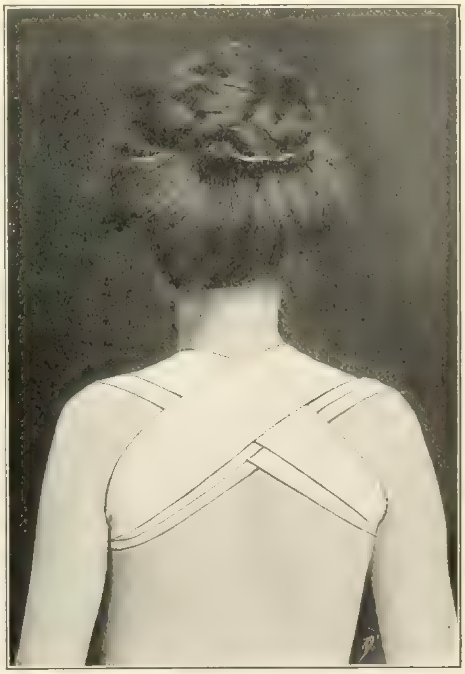
Fig. 336.—Posterior Figure-of-8 Bandage of the Chest.

Posterior Figure-of-8 Bandage of the Chest.—The initial extremity of the roller (Fig. 336) is fixed between the scapulæ at the level of the axilla and the roller is carried over one shoulder to its anterior aspect, under the axilla on that side to the posterior aspect of the shoulder, and thence back to the starting-point. In a similar manner the roller is carried around the other shoulder. These turns alternate first around one shoulder, then around the other, until the bandage is finished. The point of intersection between the scapulæ is pinned.

Spiral Bandage of the Chest.—The initial extremity of the roller (Fig. 337) is fixed by means of one or two circular turns around the chest at the level of the xiphoid cartilage. The roller then gradually ascends the chest by means of spiral turns, each turn covering in two-thirds of the preceding turn until the level of the axillary fold is reached. Here one or two circular turns complete the bandage.

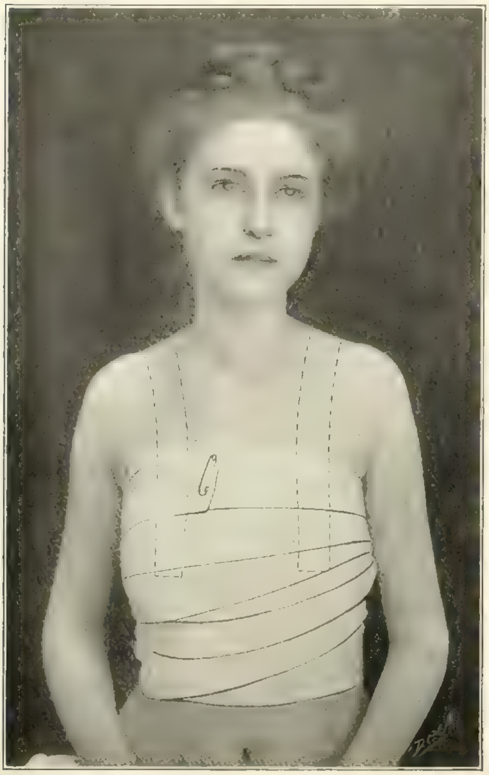

Fig. 337.—Spiral Bandage of the Chest. Additional shoulder straps are drawn on in dotted lines.

A Second Method of Completing the Bandage is to make one circular turn at the level of the axillary fold, pass under the axilla to the posterior aspect of the chest, thence obliquely to the opposite shoulder, over this to the anterior aspect of the chest, and diagonally down over the turns of the bandage to the xiphoid cartilage, where the bandage ends and is pinned. Pins are inserted to fasten this last oblique strip to each spiral turn of the bandage.

Single Breast Bandage.—The roller (Fig. 338) is started from the scapula of the affected side, is carried over the shoulder of the opposite side to the anterior chest wall, and thence under the affected breast and obliquely along the lateral and posterior chest wall to its starting-point. This turn is repeated in order to secure the initial extremity. Again, starting from the point of the initial extremity over the scapula of the affected side, the roller is carried completely around the chest just under the affected breast. These turns are alternated, each turn covering in its corresponding preceding turn by two-thirds of its width, and thus gradually ascending and covering in the breast completely. Care should be taken that the affected breast is compressed equally and that the other breast is not pressed upon.

Double Breast Bandage.—The first turn of this bandage (Fig. 339) is the same as that of the single breast bandage. The second turn is a circular one around the chest just below the breasts. The third turn begins at the point of the initial extremity, and the roller is carried around the chest wall to the under surface of the second breast; then it passes obliquely up over the anterior chest wall and over the shoulder opposite the breast thus supported, thence over the posterior chest wall to the starting-point. Turn number two is now repeated, then turn number one, then turn number three. These turns are repeated in this order, each turn covering in by two-thirds of its width the corresponding preceding turn, and in this manner both breasts are securely and neatly covered.

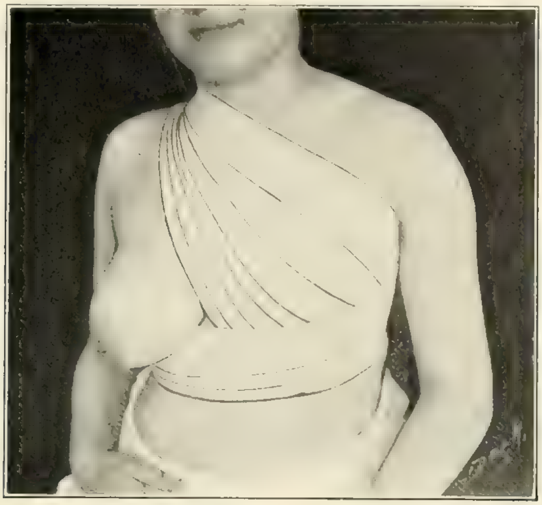

FIG. 338.—Single Breast Bandage.

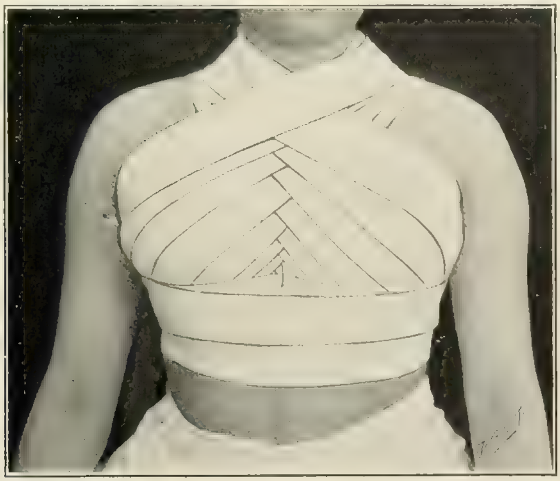

FIG. 339.—Double Breast Bandage.

Ascending Single Spica Bandage of the Groin.—The initial extremity of the roller (Fig. 340) is fixed by means of one or two circular turns around the body just above the level of the iliac crest. If the right groin is the one to be bandaged the roller should run anteriorly from left to right, and *vice versa*. The roller is carried from the summit of the iliac crest opposite the groin to be bandaged, obliquely across the anterior surface of the abdomen to the outer side of the thigh of the affected side at the junction of its middle and upper thirds. A circular turn and a half is made around the thigh at this point, the roller emerging on the inner side of the thigh and crossing the first oblique part as low down as possible in the middle line of the thigh; thence it passes over the groin to the lateral aspect of the iliac bone on the same side, and over this in a slightly oblique direction to a point above the iliac crest. A circular turn is now made around the body just above the iliac crest, as in the first turn which secured the initial extremity. The spica turns and the circular turns around the thigh are alternated with the circular turns around the body, the two former ascending by one-third of the width of the bandage. In this manner the upper third of the thigh and all of the groin are completely covered in. Either the circular turn around the body or that around the thigh, or both, may be omitted. The spica turns should cross each other exactly in the middle line of the thigh and groin. If, in bandaging the right thigh, the bandage is started around the body from right to left, instead of from left to right, the roller will then of course be carried obliquely across the

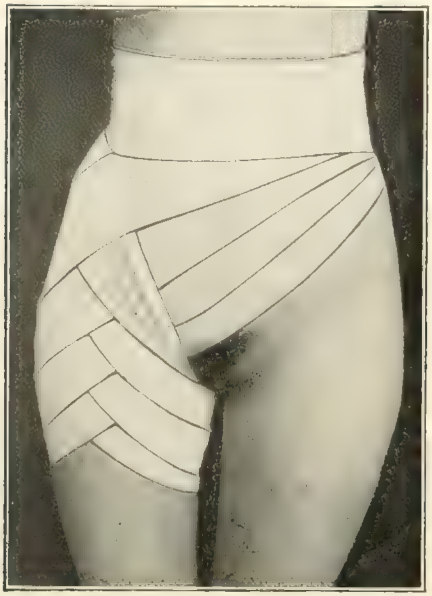

FIG. 340.

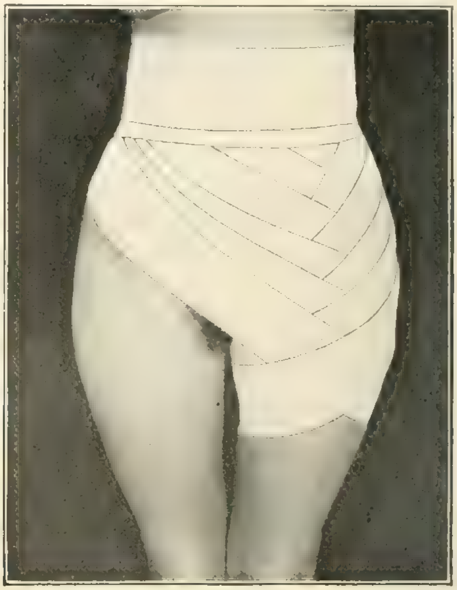

FIG. 341.

FIG. 340.—Single Spica Bandage (Ascending) of Groin.
FIG. 341.—Descending Spica Bandage of the Groin.

groin from the lateral surface of the iliac crest of the affected side to the internal aspect of the thigh at the junction of its middle and upper thirds, where a circular turn and a half is made. The roller emerging on the outer side of the thigh is carried obliquely across the anterior surface of the thigh, crossing the first oblique part of the spica turn in the middle line of the thigh as low down as possible, and is carried obliquely across the anterior surface of the abdomen to above the iliac crest of the opposite side and thence circularly around the body to its starting-point. If, in bandaging the left groin, the roller is started from the left to the right, the above description also holds good for that side.

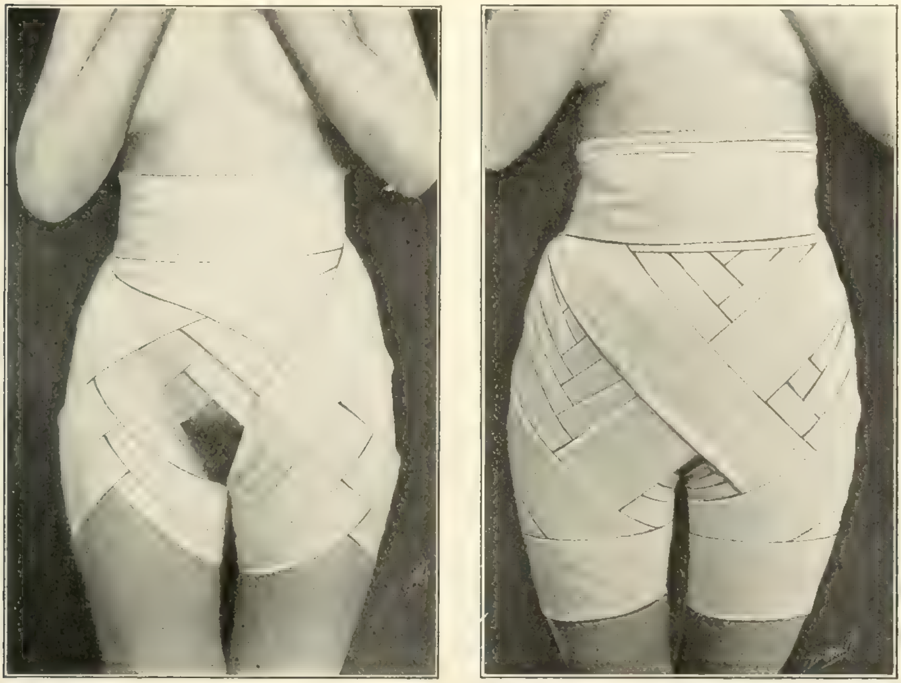
Fig. 342. Fig. 343.

Fig. 342.—Ascending Spica Bandage of Both Groins.
Fig. 343.—Descending Spica Bandage of Both Groins.

Descending Single Spica Bandage of the Groin.—The descending spica of the groin (Fig. 341) is applied in the same manner as the ascending, and consequently the same description holds good for both, with the exception that, whereas in the case of the ascending spica the first turn is placed at the junction of the middle with the upper third of the thigh, and the subsequent spica turns ascend from that point by one-third of their width, in the case of the descending spica the first turn is placed as high in the groin as possible and the subsequent spica turns descend by one-third of their width until the junction of the middle with the upper third of the thigh is reached.

Ascending Spica Bandage of Both Groins.—The initial extremity of the bandage (Fig. 342) is fixed by means of one or two circular turns around the body just above the level of the iliac crests. The roller runs from left to right, or from right to left, according to the thigh which is to receive the first spica turn. Starting from the iliac crest of one side the roller is carried obliquely across the anterior surface of the abdomen and groin to the external surface of the opposite thigh at the junction of its middle and upper thirds. Here a circular turn and a half is made, the roller emerging from the inner side of the thigh and passing obliquely across the first part of the spica in the middle line of the thigh as low down as possible, then obliquely ascending to the lateral surface of the iliac bone of the same side, thence obliquely around the body posteriorly to the opposite iliac crest. A circular turn is made around the body and the bandage is carried only to the iliac crest opposite the groin yet to be bandaged. The roller is then carried obliquely across the back to the lateral aspect of the iliac bone of the opposite side, and thence obliquely over the anterior surface of the groin of that side to the anterior surface of the thigh at the junction of its middle and upper thirds, where a circular turn and a half is made. The roller then emerges on the external surface of the thigh and ascends obliquely over the anterior surface of the groin, crossing the first oblique part of the spica turn in the middle line of the thigh. Thence the roller is carried obliquely over the anterior surface of the abdomen to the opposite iliac crest, where a circular turn is made around the body. These turns are repeated in the following order: first, a circular turn around the body; then a spica turn around one groin, the bandage emerging from the inner side of the thigh after surrounding it; then a circular turn around the body, and a spica turn around the other thigh, the bandage emerging from the outer side of the thigh after surrounding it by a circular turn; then, finally, a circular turn around the body, until both groins and the upper third of both thighs are completely covered in. The circular turns about the body accurately overlie each other, and the circular turns about the thighs ascend by one-third of their width. Either the circular turns around the body or the circular turns around the thighs or both may be omitted.

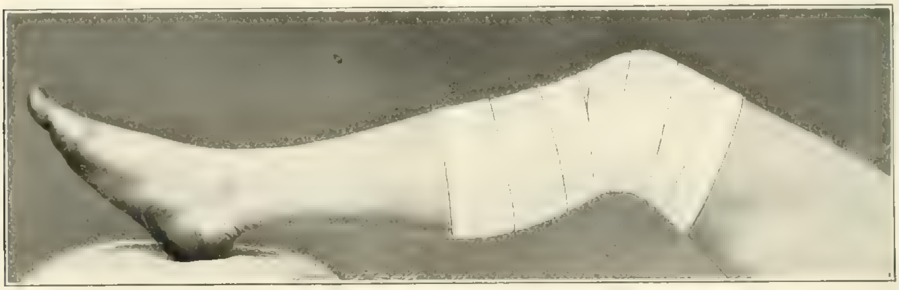

Fig. 344.—Figure-of-8 Knee Bandage.

Descending Spica Bandage of Both Groins.—The descending spica of both groins (Fig. 343) is applied in the same manner as the ascending spica, with the exception that the oblique turns in the descending spica begin to cross high up in the groin and descend to the junction of the middle with the upper third of the thigh.

Figure-of-8 Bandage of the Knee.—The initial extremity of the bandage (Fig. 344) is fixed by means of one or more circular turns around the thigh a short distance above the knee joint. The roller is carried obliquely across the popliteal space to the inner surface of the leg and surrounds the leg by a circular turn about three inches below the knee joint. The roller is then passed obliquely upward across the popliteal space, crossing the first oblique turn in the middle line to the inner surface of the thigh, where a circular turn is made which overlaps the preceding circular turn at this point by two-thirds of the width of the bandage and approaches the knee joint by one-third of its width. The popliteal space is again crossed to the circular turn below, and here is made another circular turn which ascends toward the knee joint by one-third of the width of the bandage. These turns are continued first above and then below the knee, the upper ones gradually descending and the lower ones gradually ascending until the knee is entirely and securely covered.

Figure-of-8 Bandage of Both Knees.—The patient's knees are placed closely together, being separated only by a layer of non-absorbent cotton or some soft material to protect the opposing bony prominences from pressure. The initial extremity of the bandage is fixed by means of one or two circular turns which include both thighs at a short distance from the knee joints. The roller is carried obliquely across both popliteal spaces to a point about three inches below the knees, where a circular turn is made around both legs. The popliteal space is again obliquely crossed by the roller and a circular turn is made around both

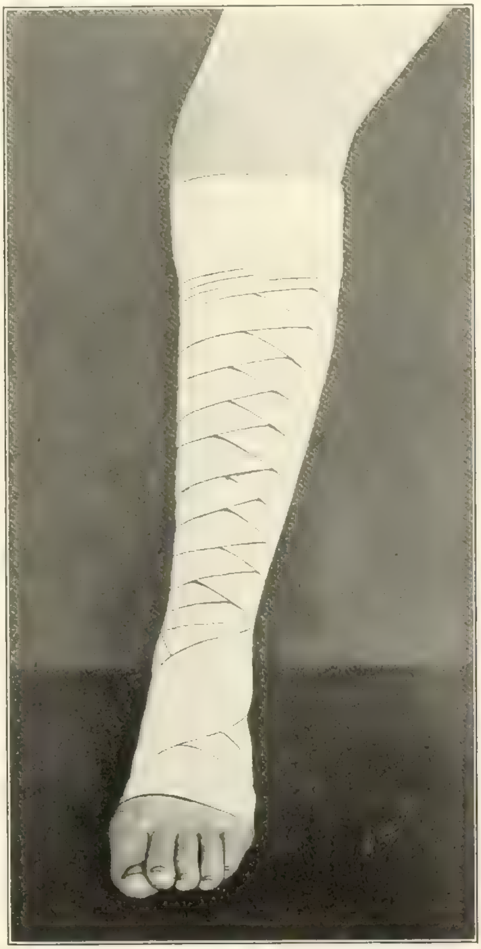

FIG. 345.—Reversed Spiral Bandage of the Leg. (In the drawing the turns of the bandage should have been carried farther down on the toes.)

the thighs, this turn overlapping the previous turn by two-thirds and descending toward the knees by one-third of the width of the bandage. Again, the popliteal spaces are crossed to the turn below the knees and a second circular turn is made there, this turn overlapping the previous one by two-thirds and ascending toward the knees by one-third of its width. These circular turns are repeated, first one above and then one below the knees, until the parts are completely covered. Finally, to complete the bandage, the roller is passed from the posterior surface between the thighs to the anterior surface of the bandage, over this to between the legs, and so posteriorly to emerge between the thighs, and is fastened on the anterior surface.

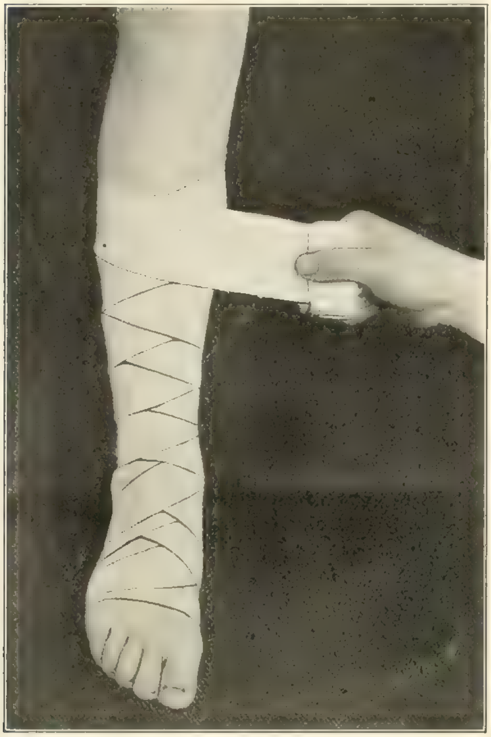

FIG. 346.—Short Figure-of-8 Bandage of the Leg. (In the drawing the turns of the bandage should have extended farther down on the toes.)

Reversed Spiral Bandage of the Lower Extremity.—One of the foot bandages is first applied. Instead of ending the foot bandage at the ankle, the roller (Fig. 345) is carried up the leg by means of spiral or spiral reversed turns, according to the conformation of the part, until the knee is reached; here the bandage may be ended with a few circular turns, or, with the leg in the extended position, it may be continued on up the thigh to the groin, and either end there or a spica of the groin be added for additional security. If it is desired to allow the patient's knee to remain in a flexed position, the figure-of-8 bandage of the knee may take the place of the spiral or spiral reversed turns in that region.

Short Figure-of-8 Bandage of the Leg.—If the leg is fairly well nourished this is the best bandage to use. (Fig. 346.) First apply one of the foot bandages, then ascend the leg by means of spiral or spiral reversed turns until the lower part of the calf is reached; here the figure-of-8 turns begin. The bandage is carried obliquely upward and around to the median line posteriorly, whence it is carried obliquely downward and around to the front of the leg, crossing the starting-point as near the median line as is permissible without bringing too much pressure over the long ridge of the tibia. These figure-of-8 turns are repeated, gradually ascending the leg until the calf is covered. The bandage is completed by one or more circular turns around the leg just below the knee.

Long Figure-of-8 Bandage of the Leg.—The initial extremity of the bandage (Fig. 347) is fixed by one or two circular turns around the ankle, and some form of foot bandage is then applied. When it again reaches the ankle the roller is carried so as to conform evenly to the parts by an oblique turn, but, when the knee is reached, a circular turn is made and an oblique turn is carried in a downward direction until the first circular turn at the ankle is reached. An ascending spiral turn is made at the knee and an oblique turn in the downward direction is repeated. These turns are repeated, each evenly applied according to the conformation of the limb, until the entire leg is securely bandaged. This bandage is one of the easiest of the leg bandages to apply and affords even pressure.

Figure-of-8 Bandage of the Foot and Ankle.—The initial extremity of the bandage is fixed by a circular turn or two just above the malleoli. The roller is carried obliquely across the instep to the base of the toes, where a circular turn is made and the roller is returned to a point above the outer malleolus. A circular turn overlying the first circular turn is then made. These turns are continued, one above and one below the ankle, those above gradually descending and those below gradually ascending until the instep and ankle are covered. The bandage is completed by a circular turn around the ankle.

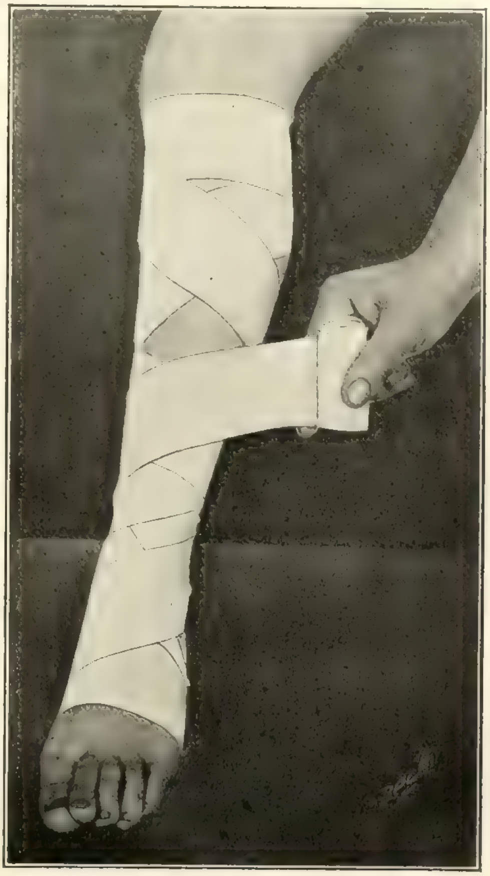

FIG. 347.—Long Figure-of-8 Bandage of the Leg. (The artist has not carried the bandage far enough down over the toes.)

Spiral Bandage of the Foot.—The initial extremity is fixed by the finger tips placed above the inner malleolus. The roller is carried around the ankle anteriorly; it crosses the initial extremity and thus fixes it. The roller now crosses the instep to the base of the toes, where a circular turn is made. Spiral turns, ascending the foot and instep, are next made as far as the conformation of the parts permits. The roller is then carried to the ankle, a few circular turns are made, and the terminal extremity is fastened.

Spiral Reversed Bandage of the Foot.—The mode of application is the same as that of the spiral bandage, except that spiral reversed turns are employed in place of spiral turns.

Spica Bandage of the Foot. (Fig. 348.)—The initial extremity is fixed by a circular turn or two above the malleoli, and the roller is carried obliquely across the instep to the base of the toes, where a circular turn is made. The roller is carried obliquely across the instep to the lateral aspect of the foot, along the lateral aspect to the posterior surface of the heel well down, thence along the lateral aspect of the foot obliquely across the instep: it crosses the instep and turns obliquely in the median line to the other side of the foot. This completes the first spica turn. These spica turns are repeated, each one ascending the foot by one-third of the width of the bandage until the foot and ankle are covered in. The bandage is completed by a few circular turns above the malleoli. It may be desirable to apply a few spiral or spiral reversed turns around the instep before beginning the spica turns, in order to make the bandage look neater. The intersection of the spica turns should always be in the median line.

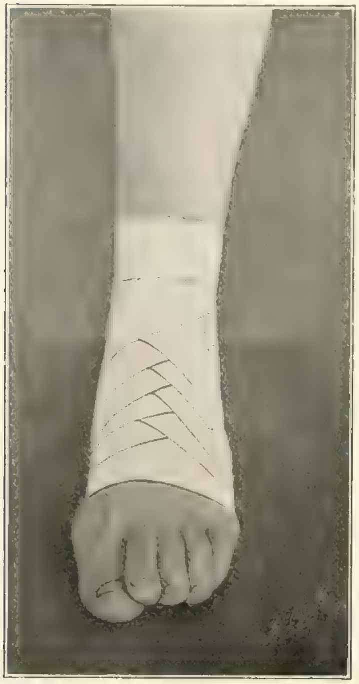

FIG. 348.—Spica Bandage of the Foot. (The turns of the bandage should have been carried down lower over the toes.)

Serpentine Bandage of the Foot.—The initial extremity of the bandage (Fig. 349) is fixed by means of a circular turn or two above the malleoli. The roller is carried obliquely across the instep to the base of the toes, where a circular turn and a half is made, bringing the roller to the middle line anteriorly. The roller is carried obliquely to the outer edge of the sole, then under the hollow arch of the foot to the internal lateral aspect of the heel, well down, thence obliquely up over the posterior aspect of the heel to the external malleolus, and obliquely to a point above the malleoli, where a circular turn is made. This forms turn number one. The roller is now carried obliquely across the instep to the base of the toes, the roller naturally going to the internal aspect of the base of the toes, whereas in turn number one it came to the external aspect. A circular turn and a half is made around the base of the toes. Thence the roller is carried obliquely over the instep to the internal edge of the sole of the foot, then onward beneath the hollow arch of the foot obliquely to the external lateral aspect of the heel, well down, thence obliquely up over the posterior aspect of the heel to the internal malleolus, and obliquely to a point above the malleoli, where a circular turn is made. This forms turn number two. (Fig. 350.) Turn number three is a circular turn around the instep and point of the heel, the edges of which are held and covered in by a repetition of turns number one and two, thus completely covering in the heel. Turns number one, two, and three are repeated until the parts are sufficiently covered. If it is not desired to cover in the heel, the circular turn number three may be omitted. This forms the most efficient foot bandage.

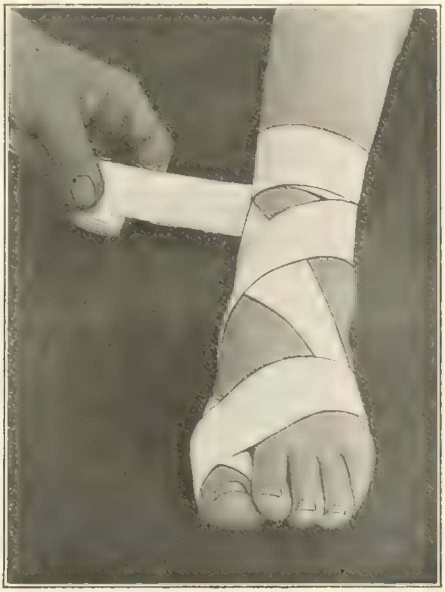
FIG. 349.—Serpentine Bandage of the Foot, First Turn.

Recurrent Bandage of the Foot.—Any of the usual foot bandages may have included recurrent turns for the purpose of covering the toes. *Combinations* of spiral, spiral reversed, spica, figure-of-8, recurrent, and serpentine bandages of the foot may be used as indications arise in individual cases. It may sometimes be necessary to carry spiral or spiral reversed turns above the ankle.

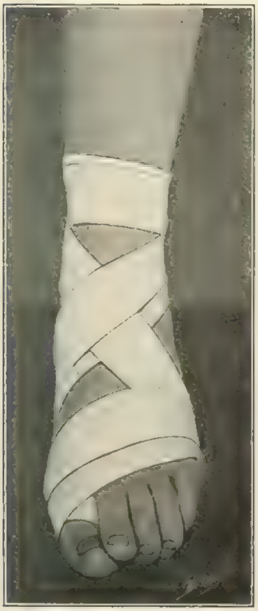
FIG. 350.—Serpentine Bandage of the Foot, Second Turn.

Spica Bandage of the Great Toe. (Fig. 351.)—This is applied in a manner similar to that employed in applying a spica of the thumb. The initial extremity is fastened by one or two circular turns above the malleoli. The bandage then crosses the instep obliquely from above the internal malleolus to the outer side of the great toe. A circular turn is made around the great toe, as near the tip as possible, and the roller is carried from the inner side of the toe obliquely across the instep; it crosses the first oblique part of the spica as near the tip of the toe as possible and passes thence above to the external malleolus. Here a circular turn is made. If desired, the tip of the toe may be covered in by a few recurrent turns. The spica turns are repeated; they ascend toward the base of the toe each time by one-third of the width of the bandage, until the toe is completely covered. The circular turns around the toe may be omitted.

Serpentine Bandage of the Great Toe.—The initial extremity of the bandage is fastened by means of one or two circular turns above the malleoli. The roller is then carried obliquely across the instep to the outer edge of the sole, obliquely under the sole to a point just posterior to the thenar eminence, then to the inner edge of the foot, and finally across the anterior surface of the base of the toe to its tip. Here a circular turn is made and a few recurrent turns may be added. From the tip of the toe the roller crosses the anterior surface of the base of the toe, and passes thence, obliquely across the base of the other toes, to the outer surface of the foot at a point opposite the hypothenar eminence. The roller passes under the sole obliquely, just behind the thenar eminence under the arch, to emerge at the inner edge of the foot, and from this point it passes obliquely across the instep to a point above the external malleolus. Here a circular turn is made. These serpentine turns are repeated, each overlapping the preceding one to a slight extent until the toe is completely covered.

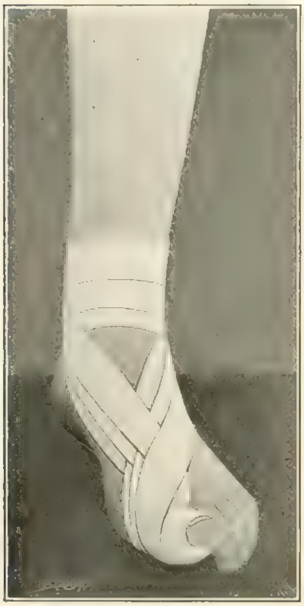

Fig. 351.—Spica Bandage of the Great Toe. (In actual practice the bandaged toe should lie quietly on the same level as its neighbor.)

Compound Bandages.—Compound bandages are used for the most part to take the place of roller bandages, for use in unskilled hands. They are usually made of unbleached muslin cut to conform to the shape of the part of the body to which they are applied. They are used in first-aid dressing on the battlefield; but few of the bandages are useful in civil practice, as they afford neither the comfort nor the security of the well-applied roller bandage. Of those used in civil practice the sling is the one most frequently employed. For supporting the forearm, a yard square of unbleached muslin is cut diagonally, two triangular slings thus being provided; or the yard square may be folded diagonally on itself, thus forming a triangle. The apex of the triangle is applied beneath the elbow, the portion of the sling next the body is carried over the opposite shoulder, the other portion over the shoulder of the affected side, and the ends are fastened by knotting them at the back of the neck. Enough traction is used to insure that the body of the triangle affords equal support to the entire length of the forearm. The apex of the triangle is secured to the front of the sling. To afford additional security the two sides of the sling may be sewed or pinned together just above and parallel with the forearm. (Fig. 352.)

Another variety of sling for the upper extremity is made by using a strip of muslin three feet in length and of sufficient breadth to support the forearm. A bandage or binder of the chest is first applied, one end of the sling being pinned in front to the median line of the binder or bandage. The other end is passed between the body and the arm, beneath the latter, and around it to the starting-point, where it is pinned with enough traction to support the arm comfortably.

Sling for the Lower Extremity.—A long external, well-padded board splint, ten inches broad and extending from the axilla to a point below the heel, is secured to the chest and pelvis by a bandage of adhesive plaster. A strip of muslin broad enough to surround the lower extremity is used. One edge of the long side is tacked to the uppermost edges of that portion of the splint which corresponds to the leg and thigh. The strip is then passed under the leg and thigh back to the first edge and there fastened, sufficient tension being used to support the limb comfortably.

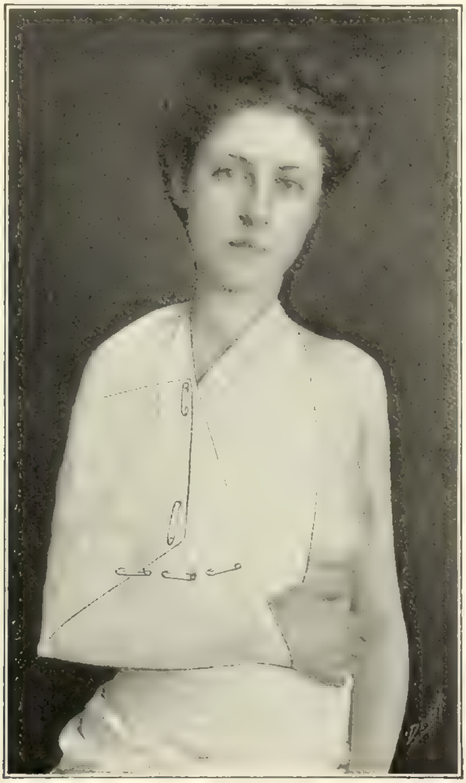

FIG. 352.—Arm Sling.

T-bandages are mostly used for holding perineal or vulvar dressings in place. (Fig. 353.) They may be modified to secure dressings in other parts of the body, such as the head and face.

The Single T-bandage (Fig. 354) is made by sewing a strip of unbleached muslin, three inches wide by eighteen inches long, to the middle of another strip four inches wide by forty inches long. The edges should be hemmed.

The Double T-bandage (Fig. 355) is made by sewing two short strips to the middle of the long strip. The long strip or body of the bandage may be made wider according to the part of the body to which it is intended to apply it. The two strips may be fastened throughout a short distance to each side of the middle of the body of the bandage.

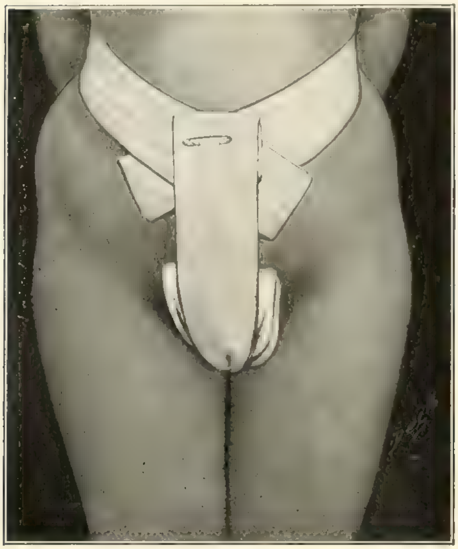

FIG. 353.—T-Bandage, Applied.

Triangular Bandages are modified T-bandages. The vertical strip of the single T-bandage is made broad at the base and triangular in shape, the base being attached to the body of the bandage. This form of bandage is useful in securing dressings in the region of the groin (Fig. 356), in the gluteal region, and in the anal region. In applying a T-bandage to retain dressings against the perineum, or against some part in that neighborhood, the body of the bandage is first made to surround the pelvis and then is fastened in the median line in front. The vertical strip or strips are then drawn taut from behind forward over the dressing and are secured to the body of the bandage over the lower part of the abdomen.

When the *T-bandage of the Chest* (Fig. 357) is applied, the body of the bandage, ten or twelve inches broad, is made to surround the chest, being fastened by pins in the median line in front. The vertical strips are then brought from behind forward snugly over the shoulder and fastened to the body of the bandage in front.

The Abdominal T-bandage or Abdominal Binder (Fig. 358) is made of two thicknesses of unbleached muslin, or of one thickness of canton flannel, in several sizes, from ten to eighteen inches wide, by $\frac{3}{4}$, $\frac{7}{8}$, 1, $1\frac{1}{8}$, $1\frac{1}{4}$, and $1\frac{1}{2}$ yards long. The body of the bandage surrounds the abdomen and pelvis, the lower edge of the body of the bandage reaching well down on the thighs. It is secured in front with safety-pins and the vertical strips are passed from behind forward between the thighs and fastened anteriorly to the body of the bandage, thus securing it and preventing it from slipping up upon the abdomen. These

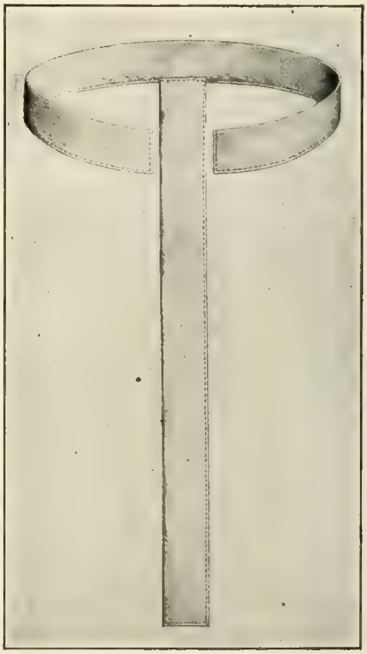

FIG. 354.—T-Bandage (Single).

strips are called perineal straps, and, instead of being originally part of the bandage, they may be pinned in place after the body of the bandage has been applied so as to permit of their easy removal should they become soiled. The abdominal binder is made to conform more snugly to the parts by pleating with safety-pins on each side.

Hernia Bandage.—This is made by lengthening the body of an ordinary triangular bandage sufficiently to allow the body of the bandage to encircle the body twice. A three-inch roller is attached to the apex of the triangle, and this is used as a spica of the groin after the triangle is applied.

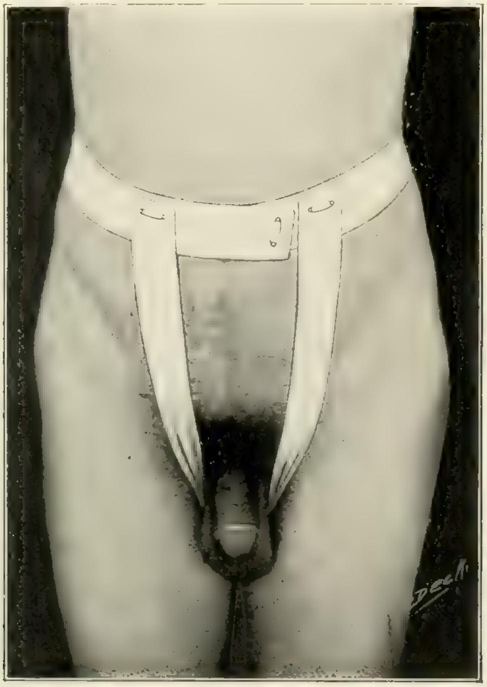

Fig. 355.—Double T-Bandage Applied.

The Breast Binder (Fig. 359) should be made of two thicknesses of unbleached muslin or of one thickness of canton flannel. It resembles an armless jacket. The dimensions are: length, one yard and one-fourth; width, at the back, sixteen inches, in front eleven inches, under the arms nine inches. The body of the bandage surrounds the chest and is secured by pinning in the median line in front. The portions corresponding to the strips of the T-bandage of the chest are fastened over each shoulder with safety-pins. (Fig. 360.) The bandage is made to fit snugly by taking pleats in the sides with safety-pins. This bandage is most frequently used, after a radical operation for carcinoma of the breast, to retain dressings and to afford support to the opposite breast.

Four-tailed Bandage.—This is a modification of the T-bandage. It is made by

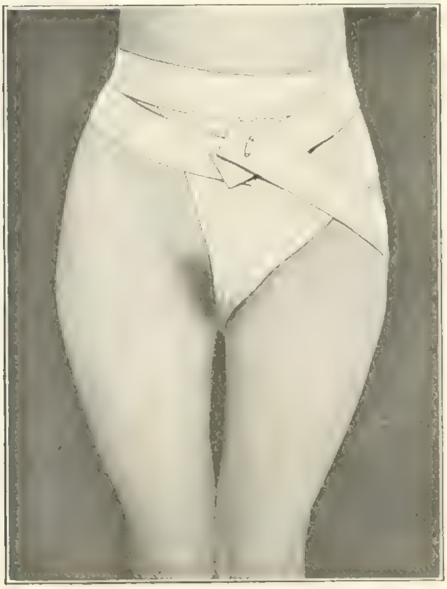

Fig. 356.—Triangle of Groin.

splitting in two and tearing longitudinally a strip of bandage four inches broad by three feet long. Each end is split longitudinally up to a point within four inches of the middle of the strip. The unsplit portion is the body of the bandage. Such a bandage is useful in retaining certain fractures of the jaw in position, and for dressings in the region of the chin. (Fig. 361.) The body of the bandage is applied to the symphysis of the upper jaw. The upper two of the four tails are carried directly backward to beneath the inion and are there drawn taut and knotted. The lower two of the four tails are carried directly upward until the vertex of the skull is reached, where they are drawn taut and knotted. The four ends are then tied tightly together and the superfluous part of the bandage is cut away.

Retractor Bandages.—Modifications of the T-bandages are used for the purpose of retracting the soft parts in amputations, in order to prevent injury to the soft parts while section of the bone is made. They are two-tailed for amputations of the humerus or femur, and three-tailed for amputations of the forearm or leg. They are made of several thicknesses of unbleached muslin, each tail measuring twenty inches long by eight inches wide.

The Scultetus (Fig. 362) is another form of many-tailed bandage. That most frequently used is similar to an abdominal binder, the binder being split into many tails from each extremity to a point within four inches of either side of the middle line of the bandage. Such a bandage is useful in retaining dressings upon an abdom-

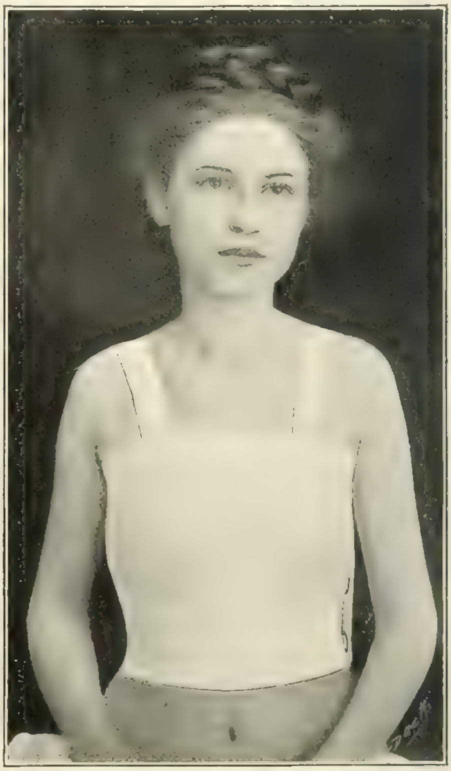

Fig. 357.—T-Binder for the Chest.

inal wound and in exerting even pressure during paracentesis abdominis. In the latter case, as the fluid is withdrawn from the abdomen the tails of the bandage are drawn tighter and tighter so as to exert even pressure upon the abdomen. When the scultetus is applied for retaining abdominal dressings the lower tails of the bandage are first brought across the lower part of the abdomen and fastened, then the other tails are alternately brought into place, first from one side and then from the other side, from below upward. (Fig. 363.)

Fixation Bandages.—Bandages in which are incorporated materials that finally harden have been in use since the middle ages. The old Arabic physicians Albugerig, Athuriscus, and Rhazes used bandages in which were incorporated albumen, gypsum, and chalk. The use of such bandages was apparently common in the Orient for centuries. Larrey, in the course of Napoleon's Egyptian campaign, found the Egyptians using a hardening mixture of white of egg, camphor spirits, and subacetate of lead in cases of fractures from gunshot injury. He mentions that the Greeks for a long time had used a retentive bandage made of a mixture of mussel shells, chalk, albumen, oil, and hemp. These bandages were removed by employing the solvent action of a steam bath. In 1798 the English Consul Eaton, stationed at Bassora, reported that the native surgeons had been successful in healing a complicated fracture of the leg in a soldier by means of plaster of Paris. This was a case in which the English naval surgeons were about to amputate the limb. Froriep gave further publicity to these facts in 1817, and two Berlin surgeons, Kluge and Dieffenbach, 1828, made experiments with the plaster-of-Paris bandage. Their methods were so crude that the treatment was abandoned. The extremity was oiled and placed in a long wooden chest which was filled with a pulp of plaster of Paris. After the hardening had taken place the lateral boards of the box were removed. A Belgian surgeon, Seutin,

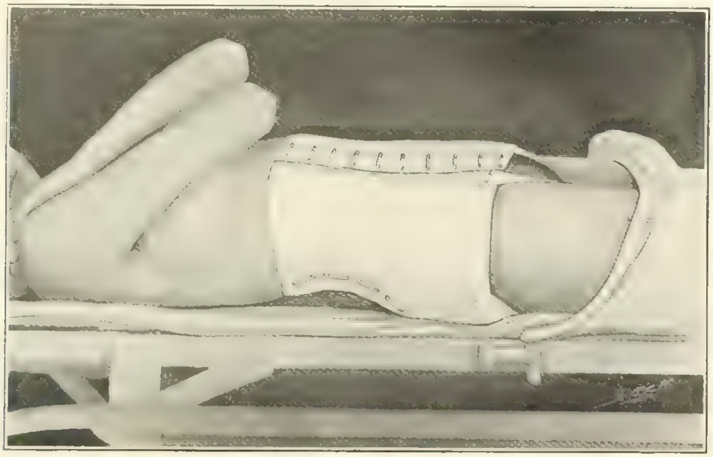
FIG. 358.—Abdominal Binder, Showing the Perineal Straps.

wrote on the subject in 1844. Two Dutch surgeons, Mathysen and van der Loo, in 1848 developed the plaster-of-Paris bandage as it is used to-day. (Hueter.)

Pirogoff and Szymanowski recommended the use of plaster-of-Paris compresses in place of the bandage—*i.e.*, linen strips dipped in a paste of plaster of Paris. This form has the advantage of being cheaper, especially if the skin is only oiled and not bandaged previous to the application of the plaster compresses. It has the disadvantage, however, of making a dressing that is very clumsy and that can be removed only with difficulty. Narrow plaster-of-Paris strips, made moist, practically do all that a plaster-of-Paris bandage does. These folded several times may be used to strengthen weak parts of the applied plaster-of-Paris bandage, especially at the joints. Pasteboard splints dipped into warm water may be adjusted at the weak places, or a rigid splint of iron or iron wire

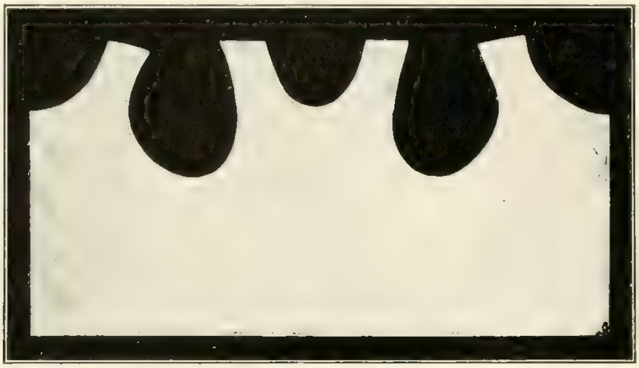

FIG. 359.—Breast Binder.

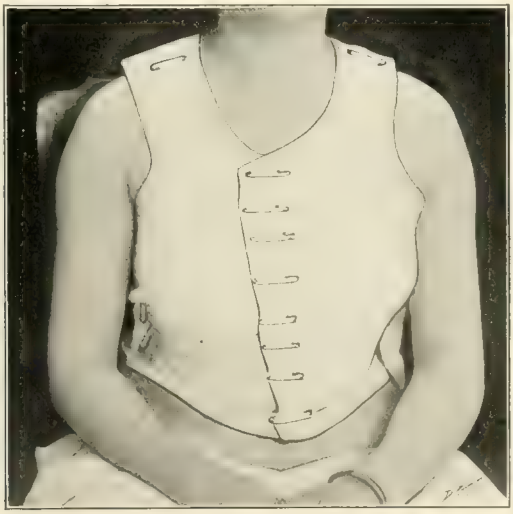

FIG. 360.—Breast Binder, Applied.

(Esmarch) may be incorporated. The incorporation of such additional splints is useful where it is desired to make a cast as light as possible. Beeley recommends that plaster-of-Paris splints be made by dipping strands of hemp into plaster-of-Paris paste.

The Bavarian splint exemplifies one of the older methods of applying plaster of Paris. Two pieces of flannel, canton flannel, or other similar material are cut to conform to the part to be enclosed and are sewn together by a double line of stitching lengthwise in the middle line. The inner of these two pieces is applied to the part and thickly coated with plaster-of-Paris paste. The outer piece is then drawn over this, and the whole moulded to the part. When the plaster has set, the dressing is cut down in the middle line anteriorly. This allows of ready removal and inspection, as the place where the two pieces of material were sewn together acts as a hinge. A much neater method of application, though more tedious, consists in applying one lateral half at a time, waiting for it to harden, and then turning the edge of the external outer half of the material over the internal half. This disposes of the necessity for cutting the cast. The whole is held in place, after hardening, by a roller bandage.

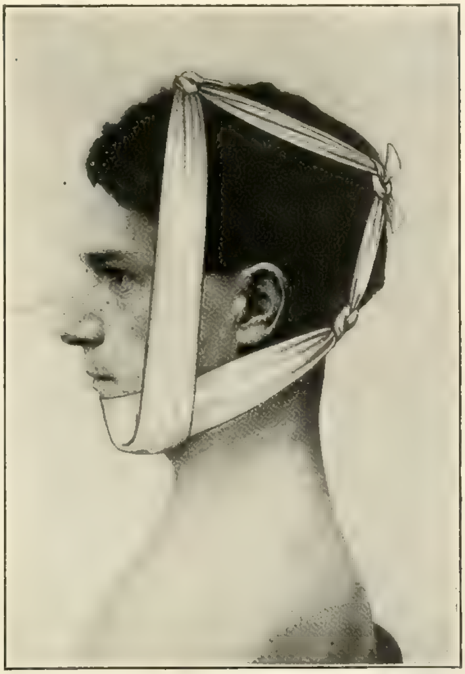

Fig. 361.—Four-tailed Bandage of the Jaw.

Manufacture of Plaster-of-Paris Bandages.—A perforated piece of tin one inch wide and of a length equal to the width of the bandage is shaped longitudinally into a triangular cage. This serves the double purpose of acting as a core upon which to wind the bandage and of allowing of a rapid and through wetting of the bandage when immersed in the solution just prior to use. Plaster-of-Paris bandages are rarely rolled by hand at the present time. A machine (Fig. 364) is used which allows of an even distribution of the plaster. Wide-meshed crinoline, two, three, or four inches wide and of the usual roller-bandage lengths, forms the best material for the bandages, as the wide meshes allow the plaster to lie in them and not on the surface of the bandage where it is liable to cake during application. The metal core is placed on the spindle of the bandage-rolling machine, and the bandage is placed on this and wound in the usual manner, except that it is loosely rolled and that it passes through the box containing the plaster of Paris and becomes impregnated with it as it is being rolled.

After rolling, the bandage is pinned to prevent unrolling, and the core is filled with plaster of Paris. Each bandage is placed in a separate metal receptacle containing plaster of Paris, or several bandages may be placed in the same receptacle. Such a box should preferably be of metal and may be made airtight by sealing with adhesive-plaster strips. Plaster of Paris should be stored in a dry place. As an additional safeguard against dampness each bandage may be wrapped in oil paper and an elastic snapped about this to retain it.

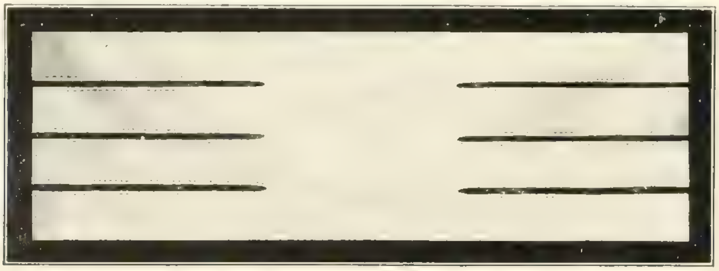

FIG. 362.—The Scultetus or Many-tailed Bandage of the Abdomen.

Measures of Precaution which Are Necessary While the Plaster-of-Paris Bandage is Being Applied.—Before the application the quality of the plaster of Paris should be inquired into. That commonly sold often contains, besides anhydric calcium sulphate, so much calcium carbonate that it does not harden to a solid mass after being mixed with water in which calcium carbonate is somewhat soluble, but crumbles. Plaster of Paris which has been overheated is useless, because it only sparingly takes up water. The plaster of Paris may be too moist and consequently is likely to have lost its anhydric qualities. The best grade

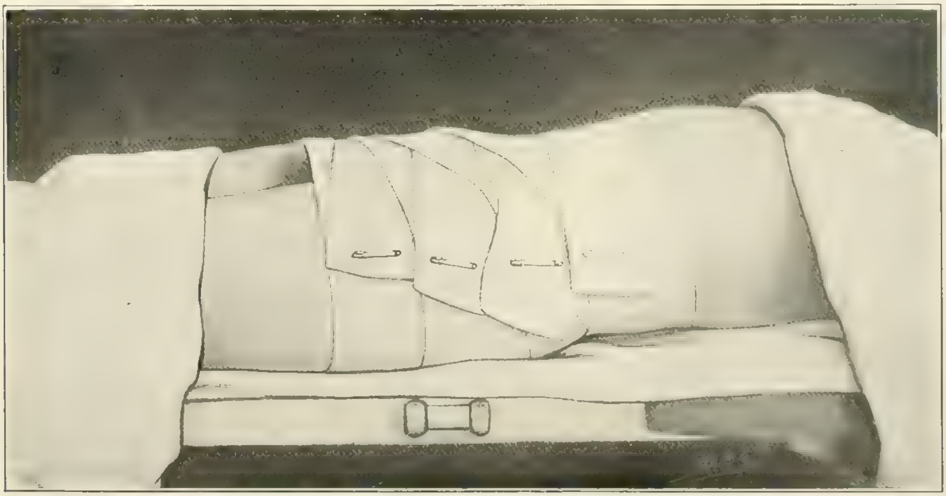

FIG. 363.—Many-tailed Bandage of the Abdomen, Applied.

of dental plaster should be used. When it has become moist it may be dried in a pan over the fire before using. Less pure plaster may be made to harden better if alum is added to the water.

The precautions which have been noted as necessary in the application of bandages, in order to prevent venous stasis, gangrene, and ischæmic muscular contracture, must be even more closely observed in the case of the plaster-of-Paris bandage, for this does not yield at all to swelling. As venous stasis increases rapidly, care must be taken that each turn of the bandage shall cover the extremity without in any way constricting it. In addition, the patient is to be very carefully watched during the first two or three days, and, in case of swelling of the peripheral portions of the limb, the bandage is to be split longitudinally. If this does not suffice, the bandage must be removed completely. This rule must be particularly observed in recent fractures treated by the primary use of the plaster-of-Paris bandage. Here the swelling consequent upon the injury may induce constriction even when the bandage has been correctly applied. This is no *ignis fatuus*. The specialist, as well as the beginner, must give strict attention to these cases, at least during the first forty-eight hours. The patient should be further instructed to report any pain or swelling at once. The bony prominences, such as the malleoli, the crest of the tibia, the tubercle of the tibia, the patella, the trochanter major, the spine of the ilium, the head of the ulna, the

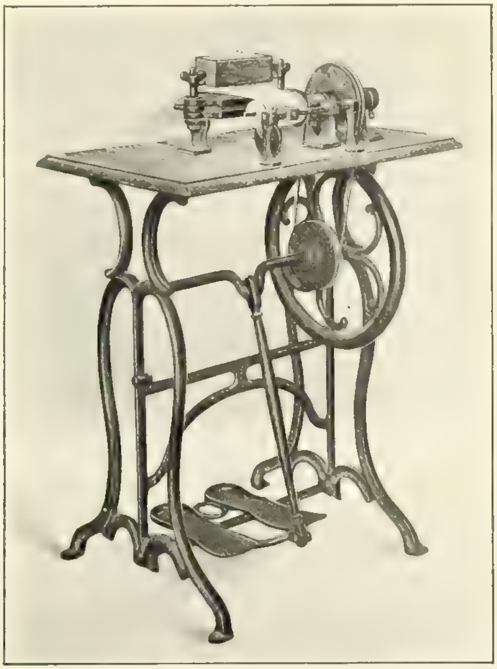

FIG. 364.—Plaster-of-Paris Attachment to Foot Machine.

olecranon, the acromion process, and the heel, must be particularly protected against pressure effects. When gauze or cotton is applied over these prominences an extensive amount must not be used, otherwise the adjustment of the plaster-of-Paris bandage will be interfered with and it would lose somewhat of its fixing effect. In case pain is complained of at one of these prominences a fenestra should be cut in the bandage, but openings should not be cut over these prominences as a precaution, for the edges of such openings press upon the soft parts and allow of swelling where the supporting effect of the bandage is lost. In case the bandage covers a wound from which discharge is expected, a fenestra should be cut over the wound; otherwise the bandage would rapidly become moistened and ruined. This is done after the hardening process is complete. The edges of such fenestræ are packed carefully with gauze and coated with collodium to prevent the discharge injuring the plaster of Paris. In applying a cast in such a case, provision may be made for dressing the wound by not covering that part of the limb. It is, however, easier and neater to cut the fenestra later.

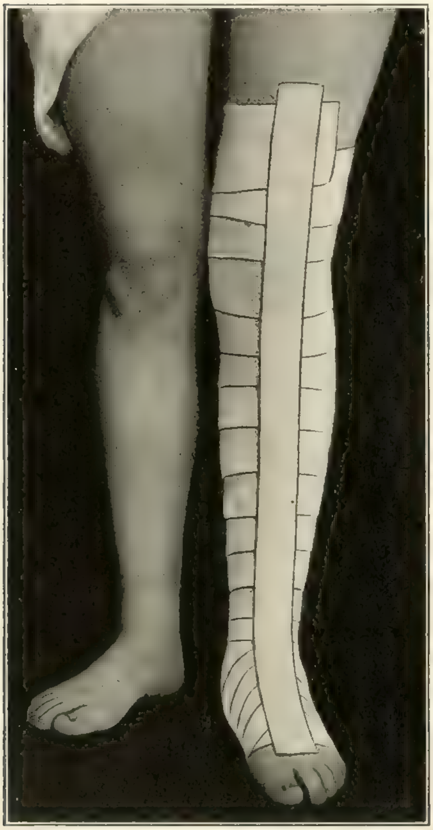

FIG. 365.—Flannel Roller and Adhesive-Plaster Strip in Place on Leg, Ready for the Application of Plaster of Paris.

Application.—The parts are placed in the exact position in which it is desired that they remain, and this position is retained during the application of the bandage and thereafter maintained by sand bags laid alongside the limb until the plaster has thoroughly hardened. The hardening process may be accelerated by allowing the draft of air from an electric fan to blow upon the bandage. In the absence of the electric fan an ordinary fan may be used.

Everything which is to be employed in the application of the cast should be at hand and within convenient reach, so that the cast may be rapidly applied. The bed should be protected by a piece of rubber sheeting, and the operator's clothes by an apron. The skin of the part is protected by coating it with vaseline and covering it with a layer of stockinet material, a cotton stocking, or a flannel roller bandage may be applied. As before noted, particular attention is paid to the protection of the bony prominences. Here pads of cotton are placed.

These may be held in place by strips of adhesive plaster or by turns of the flannel bandage. Bandages made of thin French cotton batting are preferable to flannel as a protecting bandage. On the line at which it is desired finally to cut down the cast, is placed a strip of adhesive plaster. (Fig. 365.)

A sufficient number of plaster-of-Paris bandages to form the cast are placed near a basin of hot water. The water in the basin should be of sufficient depth to allow of complete immersion of the bandages. Two bandages are laid on their side in the water. If the atmosphere is damp or if the quality of plaster is inferior, a small quantity of salt or alum may be added to the water to hasten the hardening. The bandage is left immersed until it is thoroughly saturated and is then lightly squeezed, under water, to force out air from the interstices and allow of further saturation. The bandage is then tightly squeezed to expel the excess of water. As soon as one bandage is removed from the water, another is substituted for it until the required number is reached. The bandage is applied evenly and smoothly, in the same manner as an ordinary roller bandage. More numerous turns are made near joints, as there the strain is greatest. The number of bandages used will depend on the purpose for which the cast is applied. If this be to retain a simple dressing in place, as in cases of scalp wounds with delirium tremens, one or two bandages will suffice. To secure immobilization of joints, from six to eight thicknesses may be necessary. Fractures of the leg, when the patient is allowed to walk about, require heavier casts than those in which no such strain is put upon the damaged bone. In the former instance an additional safeguard may be furnished by the introduction of a thick roll of lamb's wool, to be held in place by several additional plaster bandages. When fenestræ are required, the plaster should first be allowed thoroughly to harden. If large fenestræ are needed, the cast should be strengthened by incorporating in it one or more strips of soft iron, bent like a basket handle, at the site of the proposed fenestræ. The cast may be finished in one of two ways, either one of which enhances its appearance: The final bandage may have its selvage left

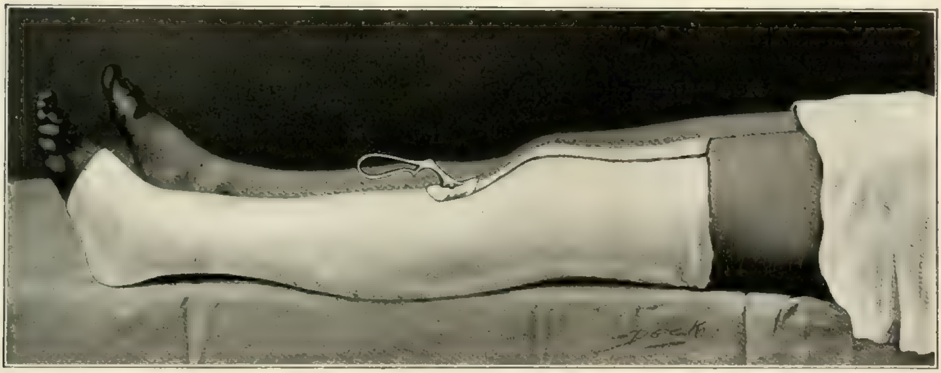

FIG. 366.—Removal of Plaster Cast.

on, and is then to be applied as a short figure-of-eight, or plaster-of-Paris paste may be rubbed in, so as to produce a smooth finish. Dry plaster may also be dusted on while the cast is still moist.

Removal.—After the cast has hardened it may be cut down at the line at which the adhesive plaster was placed. (Fig. 366.) This is desirable when the plaster is applied soon after the receipt of a fracture, as it allows somewhat for swelling and also allows of the cast being sprung apart by the hands in case swelling becomes more pronounced. The cast thus cut down is held in place by a gauze bandage. If it be cut down when its period of usefulness is past, the projecting ends of the adhesive-plaster strip serve as a guide to the line along which to cut, and guard the skin against injury from the instrument employed.

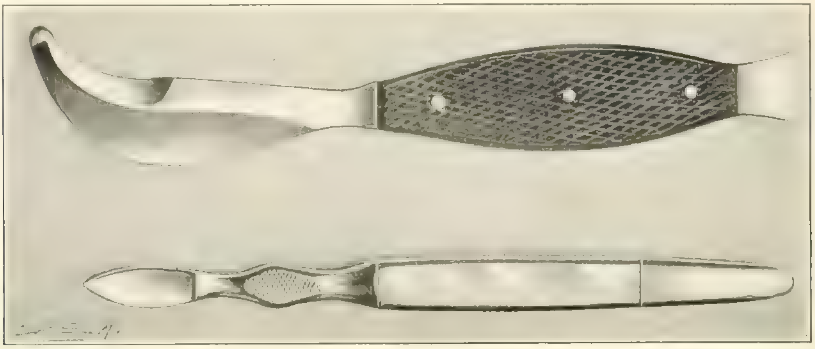

Fig. 367.—Knives for the Removal of Plaster-of-Paris Casts.

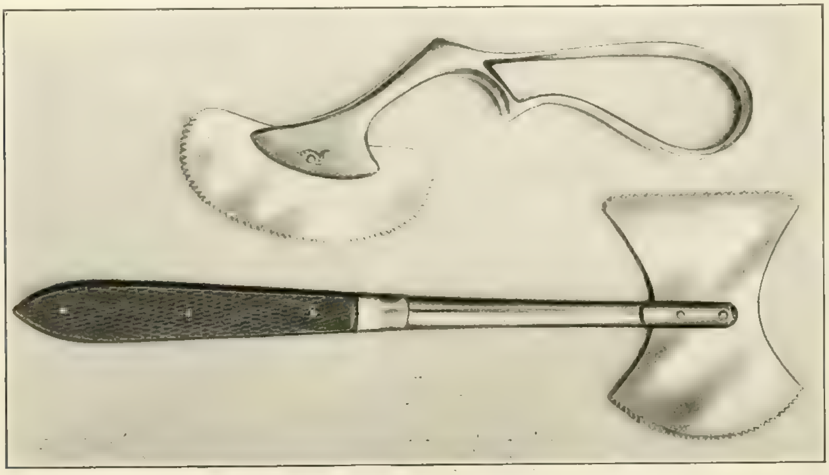

Fig. 368.—Saws for the Removal of Plaster-of-Paris Casts

Many instruments have been devised (Figs. 367–370) for removing casts. Those commonly employed are the strong resection knife, with an elevator handle, and the small hand saw. If the cast is cut down with a knife it will be found easier if the cut is made somewhat obliquely to the surface. Painting the proposed line of incision with vinegar facilitates removal, but this should not be done if it is intended to replace the cast, as the vinegar softens the plaster throughout quite a distance. The sensation conveyed by the knife or saw will tell the operator when the plaster has been entirely cut through, as the instrument will catch in the soft protecting material beneath.

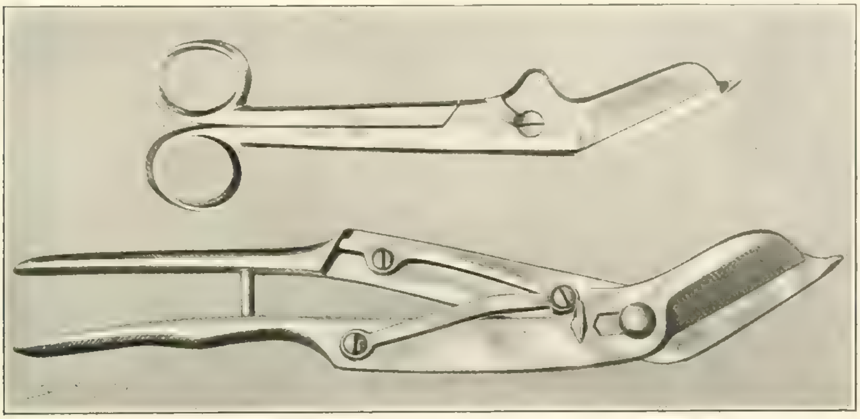

Fig. 369.—Scissors to Assist in the Removal of Plaster-of-Paris Casts.

When the cast has been completely cut through, the edges are pried apart sufficiently to allow them to be grasped with the fingers and then separated widely. The protecting dressing is then cut through, and the entire dressing, cast and all, is held widely separated while an assistant lifts the part out of the cast. This mode of procedure is desirable in order to disturb the parts as little

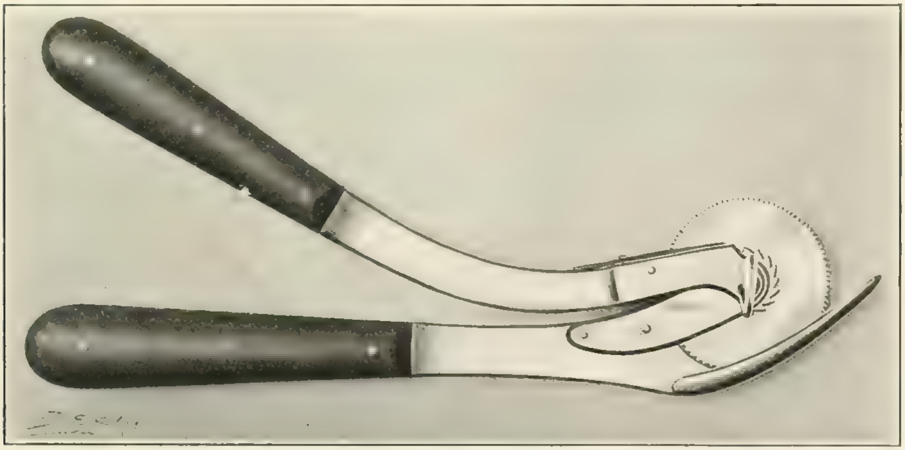

Fig. 370.—French Saw for Removing Plaster-of-Paris Casts.

as possible. If it is decided to replace the same cast the edges may be bound with adhesive plaster and, after the apparatus has been reapplied, it may be held in place with a muslin bandage.

Either vinegar or sugar water will be found useful in removing plaster from the operator's hands. Vaseline rubbed into the subungual spaces and about the nails helps to keep the plaster from adhering.

Plaster Splints.—These may be made in two ways. A cast may be applied as described and, after it has hardened, it may be removed in two sections. These are to be well padded and the edges are to be bound with adhesive plaster; the entire splint is then held in place by adhesive plaster and a muslin bandage. A second method is to fold the bandage on itself on a smooth surface, thus forming a flexible splint of the desired width, length, and thickness. One or more of these splints are moulded to the parts in such a manner as to permit of ready removal. While hardening they are held in position by a few turns of a gauze bandage. After they have become hardened they are lined with cotton, applied to the part, and held in position by adhesive plaster and muslin bandages.

Starch Bandages.—Seutin, a Belgian surgeon, in 1884, advised the use of starch bandages as a removable immobilizing dressing. Originally, gauze bandages were soaked in fresh starch, and the starch was spread between the bandage turns as they were applied. Now, however, crinoline bandages are used, these containing, as a rule, enough starch to act as a hardening dressing. If the amount of starch is deficient, powdered starch may be incorporated in the meshes of the bandage. Before application the bandage is immersed in hot water and applied wet.

Application.—The limb is first bandaged with an ordinary flannel bandage, or, in the case of the lower extremity, a stocking may be put on. A strip of adhesive plaster is placed longitudinally along the anterior aspect of the limb in the median line, and a second strip along the posterior aspect in the median line. These strips extend for the full length of the proposed bandage, and serve to protect the limb when the starch cast is cut in two portions. Several layers of the starch bandage are applied in the same manner as is done in the case of a plaster-of-Paris bandage. Such a dressing has the advantage of lightness, but it possesses the disadvantage of becoming firm only after from twenty-four to forty-eight hours, during which time it must be protected. For the purpose of maintaining the parts in position during hardening of the starch, wooden splints may be employed; or an outer layer of plaster of Paris, which is removed after forty-eight hours (Rosen), may be used. The starch cast has the additional advantage of being readily cut with stout scissors.

Soluble-Glass Bandages.—This form of fixed dressing is cheaper and lighter than plaster of Paris, but, as it takes twenty-four hours to become firm, neither it nor the starch bandage can replace plaster of Paris in the treatment of recent fractures or for use in the correction of deformities. Both these forms of bandage, however, can be very profitably employed as a later supporting dressing in fracture cases and in cases of resection of a joint. As in the case of the starch bandage, the soluble-glass bandage must be supported for from twenty-four to forty-eight hours either by wooden splints or by a few turns of a plaster-of-Paris bandage. The application of the soluble-glass bandage is quite simple. The liquid is poured into a basin, and a number of gauze bandages are placed in the solution until they become saturated. It is necessary to protect the skin against the action of the liquid either by means of a flannel bandage or by the use of a stocking, as the liquid contains, in addition to the hardening potassium silicate, a greater or less amount of free potassium—an agent which affects the skin. During the application of the bandage additional liquid is poured between the layers so as to fill the meshes of the gauze. Longitudinal strips of pasteboard may be interposed to strengthen the bandage. After it has hardened, the bandage may be removed in two sections with strong scissors. There will thus be formed two splints, the edges of which may be bound with adhesive plaster and so protected against splintering. The splints are then held in apposition to the parts by means of an ordinary roller bandage. Less commonly, magnesite is similarly employed.

Starch bandages and soluble-glass bandages have the advantage over plaster of Paris in that they are not affected by moisture, but this disadvantage of the plaster-of-Paris bandage may be overcome by rubbing the bandage with a solution of dammar resin (Mitscherlich), or soluble glass may be poured over the final layer of the plaster-of-Paris bandage. Mixtures of soluble glass and plaster of Paris harden very readily and are insoluble in water.

Paraffin Bandages.—These are not practical, as they do not afford a sufficiently solid support; furthermore, they sometimes melt at ordinary room temperatures and they irritate the skin if the paraffin remains in contact with it for a time.

Caoutchouc Bandages.—These are of advantage in young children. Strips of caoutchouc are immersed in hot water until soft, and then are rolled up with a linen roller bandage and dipped in cold water to cause them to harden as quickly as possible. The resulting bandage is light and rather firm, and is not affected by water. They have the disadvantage of being expensive. Just previous to application the bandage should be immersed in hot water.

Adhesive Plaster.—Officinal resin plaster, rubber plaster, and moleskin plaster are the varieties commonly employed.

Surgeon's adhesive plaster—rubber plaster—is now made in combination with zinc oxide, in order to render it less irritating to the skin.

Preparation.—The plaster may be used directly from the roll or it may be cut in long strips, $\frac{1}{2}$ to $\frac{3}{4}$, 2, 3, or 4 inches in width, and these strips may be rolled on glass or metal rods six or eight inches long, for convenient handling. The small strips are useful for strapping the ankle and other joints, for the treatment of leg ulcers, and for retaining dressings; the wider strips for strapping the chest and abdomen.

Adhesive plaster may be used in the form of taped straps to retain an abdominal dressing in position. (Fig. 371.) For this purpose four strips are used, each strip having a length of ten or twelve inches and a breadth of three inches. One end of each strip is folded on itself (adhesive surfaces together) for a distance of one inch; the object of this is to facilitate removal. The other end of each strip is folded on itself (adhesive surfaces together) for a space of two inches, and through this double thickness a triangular cut is made with scissors, and through the opening a half-inch tape is passed and knotted. Each tape should be long enough (eight to ten inches) to admit of being tied in a bow knot to its fellow of the opposite side over the abdominal dressing. Two of these prepared adhesive-plaster straps are placed on the skin well back on each flank. The skin should first be dried to insure thorough adhesion. By applying straps in

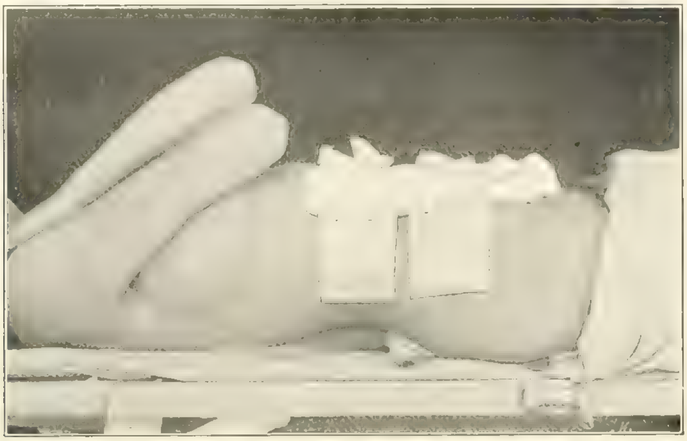

Fig. 371.—Adhesive-Plaster Taped Straps for Retaining Abdominal Dressings.

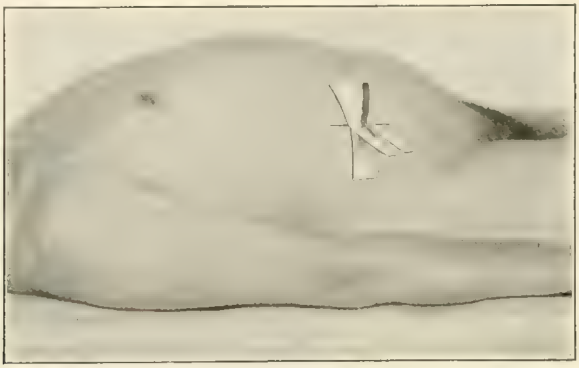

Fig. 372.—Employment of Adhesive Plaster in Securing Apposition of the Edges of a Wound.

this manner it is only necessary to untie the tapes when inspecting the dressing. This does away with the unpleasant necessity of frequent changes of adhesive plaster, and furnishes a more economical method of retaining dressings in most parts of the body. These strips are particularly useful in Syme's amputation and other foot amputations in which part of the tarsus is left. All adhesive-plaster strips should be scrupulously freed from ravelings. It is particularly these threads which tend to irritate the skin.

Adhesive plaster may be employed for the purpose of approximating the edges of a wound. (Fig. 372.) When so used the plaster should be sterilized by heat, unless it has been specifically prepared for this purpose by a reliable manufacturer. If it has not been so prepared it may be readily sterilized by passing it through a flame. In applying plaster to approximate wound edges, spaces should be left between the strips to provide for the escape of any discharge that may form.

Resin plaster, when used for any purpose, must be heated in order to make it adhere. When this form of plaster is used, the degree of heat which it may have absorbed should be tested on the back of the operator's hand before he applies the plaster to the patient's skin; otherwise blistering may result from the application of too great heat.

It is not necessary to heat rubber plaster to cause it to adhere, although it may be heated for purposes of sterilization. Strips of plaster may be used for securing dressings in place while the bandage is being applied, as in applying dressings and bandages to a circular part such as the thigh.

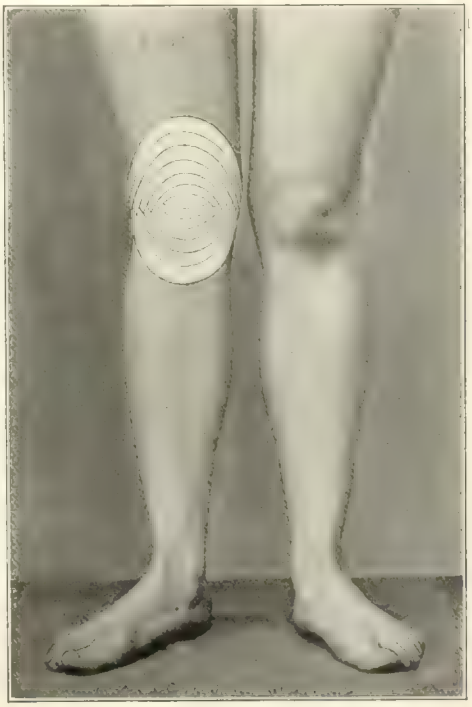

FIG. 373.—Adhesive-Plaster Strapping of the Knee in Synovitis. (Schematic.)

Adhesive plaster may be incorporated in a bandage in such a manner as to retain the bandage in position, part of the adhesive plaster being adherent to the skin and part to the bandage. Adhesive plaster is also useful for exercising direct pressure upon a part (as in strapping a joint [Figs. 373, 374] or strapping the testicle [Fig. 375]), for exerting indirect pressure (as in retaining a graduated compress in position), for securing immobilization in fractures (Figs. 376, 377), for preventing the development of deformities (as in the prevention of the equinus position of the foot in patients long confined to bed—Fig. 378), for relieving hyperæmia (as in the ambulatory treatment of ulcer of the leg—Fig. 379), for making extension (Figs. 380, 381), for preventing inversion of the lips of a deep wound (as in stout people in which there has been fat necrosis in the wound), for immobilizing fractured ribs (Figs. 382, 383), etc.

In applying the plaster to any part of the body the parts should first be cleansed and, if necessary, shaved. If it becomes necessary to apply a second strapping to a part, the plaster should, if possible, be made to avoid any irritated areas that have resulted from the first strapping. Alcohol or benzine will facilitate the removal of ordinary plaster. Benzine is an excellent solvent for plaster and may also be used for cleansing the skin after the removal of the plaster. With zinc-oxide plaster it is not usually necessary to use either alcohol or benzine. When the plaster is removed it is less painful to the patient if, after the plaster has been started, the skin is pulled away from it with one hand while steady traction is made on the plaster with the other hand. If the plaster is pulled away from the skin too rapidly and without the above precaution the edges of the plaster, where it has become most adherent to the skin, are apt to pull away some of the superficial layers of the skin, and in some instances an injury resembling a "scratch" results.

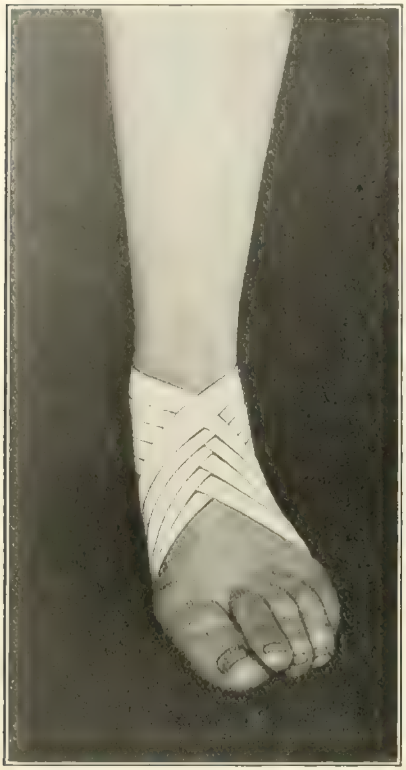
Fig. 374.—Adhesive Plaster Strapping of Ankle.

Adhesive-Plaster Abdominal Scultetus. (Fig. 384.)—This form of dressing was advocated by Boldt as a means of supporting the abdominal wall after a laparotomy and thus allowing of the earlier moving about of the patient. Zinc-oxide plaster is used to reduce skin irritation to a minimum. The quality of the plaster should be such as to preclude stretching. The full width of the plaster (twelve inches) is used and, according to the size of the patient, the strip should measure from twenty-eight to forty inches or more in length. From the centre of the lower edge of the strip a semicircular piece is cut, in order that during defecation the bandage shall not be soiled. The patient is placed upon the bandage so that the lower border comes about on a level with the pubes. The fabric covering the plaster is now removed. This is facilitated by rolling the patient first to one side and then to the other, while an assistant steadies the plaster and removes the fabric. Each end of the plaster is next split into four tails. These tails are snugly adjusted, the lower one on one side being applied first, then the lower one on the other side, and so on. These overlap, thus making a double support in front and at the sides. This process is continued until the four tails on each side have been snugly adjusted. If, in short patients, the upper part of the bandage should reach up to the epigastrium, the upper tails are not drawn so tight. The anterior superior spines of the ilia are protected by lightly padding with gauze.

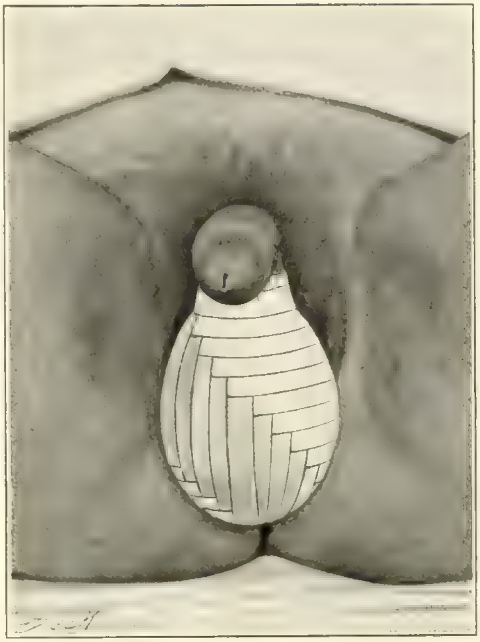

Fig. 375.—Strapping the Testicles with Strips of Adhesive Plaster.

Pressure Bandages.—Pressure bandages may be used to produce pressure, as in the treatment of varicose veins of the lower extremities; to produce hyperæmia, as in the treatment of infections (*e.g.*, tuberculous processes) occurring on the extremities; to control effusions in joints and in the soft parts, and to promote absorption of such effusions; to control hemorrhage. For such purposes an ordinary muslin roller is impracticable as it does not possess elasticity enough to produce the required even pressure, and, if tightly enough applied to exert pressure, it may produce injury to the soft parts. For producing such pressure effects a bandage possessing a certain degree of elasticity is necessary. When but a slight degree of elasticity is required, bandages of stockinet, flannel, or Japanese crêpe may be employed. Such bandages exert uniform pressure and do not irritate the skin. Where a more pronounced pressure effect is indicated, an India-rubber or a cotton-elastic bandage should be used.

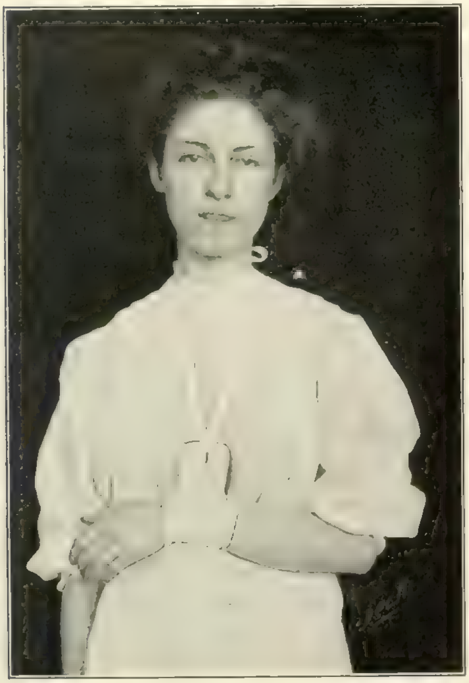

Fig. 376.—Application of Adhesive Plaster in Colles' Fracture.

The dimensions of the bandage vary with the purpose for which it is to be used. A *Martin's India-rubber bandage* is the one commonly employed in cases of varicose veins. When it is desired to render the extremity bloodless a thick rubber bandage—*Esmarch bandage*—is employed. For the immediate control of hemorrhage occurring in the course of an extremity, and for the control of hemorrhage occurring after the extremity has been rendered bloodless by the Esmarch, an *India-rubber tourniquet* is employed. This is a narrow, thick India-rubber band having a chain attached to one end and a hook to the other, by means of which it is secured in place after having been wrapped tightly about the limb at the point where the main artery is superficial—in the case of the upper extremity, well up to the axillary fold; in the case of the lower extremity, well up to the groin. Over the course of the artery is first placed an ordinary roller bandage, and this is secured in position by circular turns of the tourniquet, which is

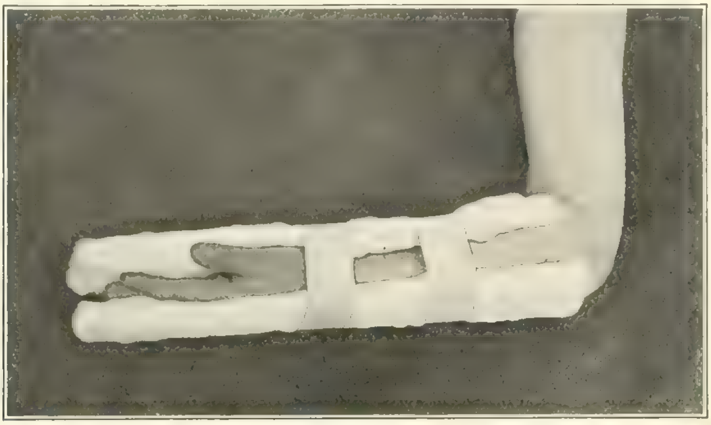

Fig. 377.—Application of Adhesive Plaster to Retain Basswood Splints.

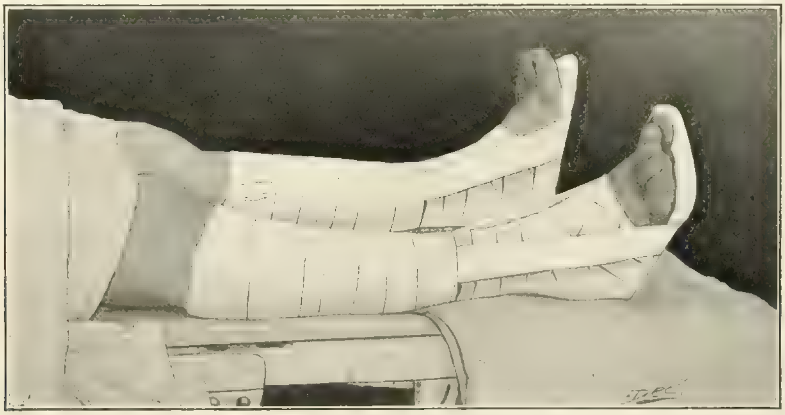

Fig. 378.—Adhesive-Plaster Straps Applied to Prevent Equinus Position in Cases of Long Confinement to Bed.

finally fastened by the hook and chain. Care should be taken that too much pressure be not employed, otherwise the skin and underlying soft parts may be injured. Some protection may be afforded by placing a folded towel around the parts before applying the tourniquet. If too extreme pressure is employed, or if the tourniquet is kept applied for too long a period, there results a vaso-motor paresis which predisposes to secondary hemorrhage. The common mistake made in applying a tourniquet is to apply it, in operations upon the forearm and hand, just above the elbow, in which event pressure upon the musculo-spiral nerve may result in paralysis; or, in operations upon the leg and foot, in applying it just below the knee, at which point pressure upon the peroneal nerve is likely to result in paralysis of the muscles supplied by that nerve.

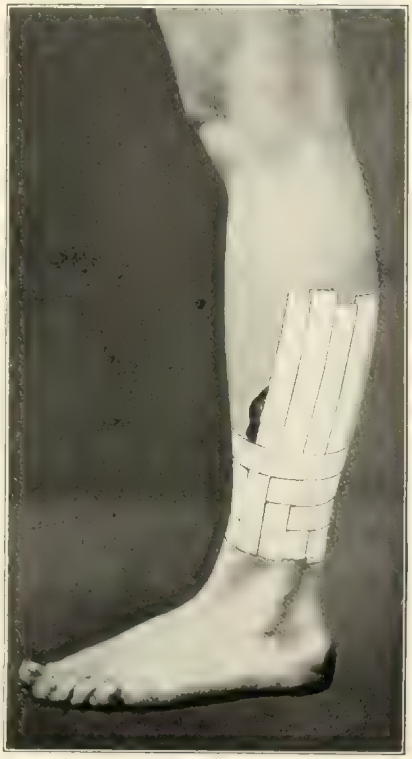

Fig. 379.—Application of Adhesive Plaster Basket Strapping for Ulcer of the Leg.

Application of the Esmarch Bandage.—The bandage is started at the distal end of the extremity and ascends by oblique turns, the edges of which just touch each other. When the entire extremity has been ascended by these oblique turns a few circular turns may be made, these circular turns being lifted up over the course of the main artery by the fingers of the left hand, and the remaining part of the body of the bandage being placed vertically under them, so that the circular turns hold the body of the bandage against the main artery and effectually shut off the blood supply. Beginning at the distal extremity the oblique turns are now unwound up to the level of the circular turns, the loose part of the bandage being bunched and held out of the way by a few turns of a muslin bandage. In operations for malignant growths or for septic conditions the bandage

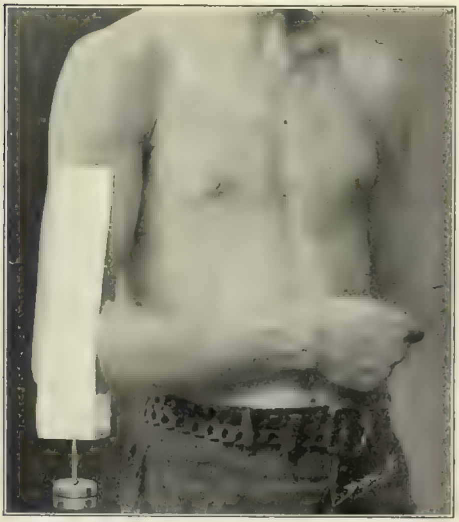

Fig. 380.—Shows Use of Adhesive Plaster in Extension for Fracture of the Humerus.

should not be applied from the distal extremity of the limb and continued up the limb, as the adoption of this course might force tumor products or septic materials into the circulation, or at least into parts of the limb not originally invaded by the disease. In such cases the limb should be elevated for five minutes and then the Esmarch bandage should be started above the level of the disease. Instead of finishing the Esmarch by inserting the body of the bandage beneath the last few circular turns over the main artery of the limb, an India-rubber tourniquet may be employed at that point and the Esmarch then entirely removed.

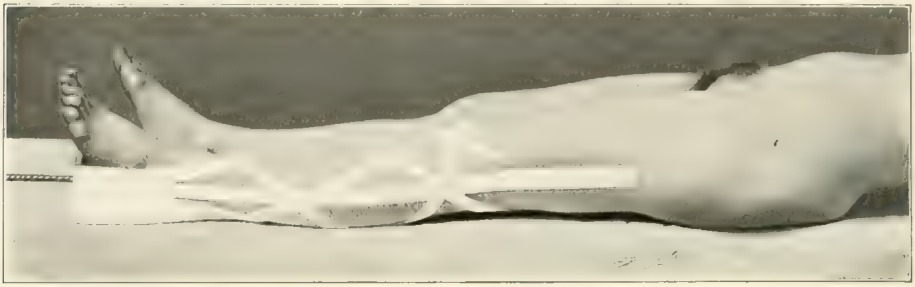

FIG. 381.—Shows Manner of Applying Adhesive Plaster in Buck's Extension.

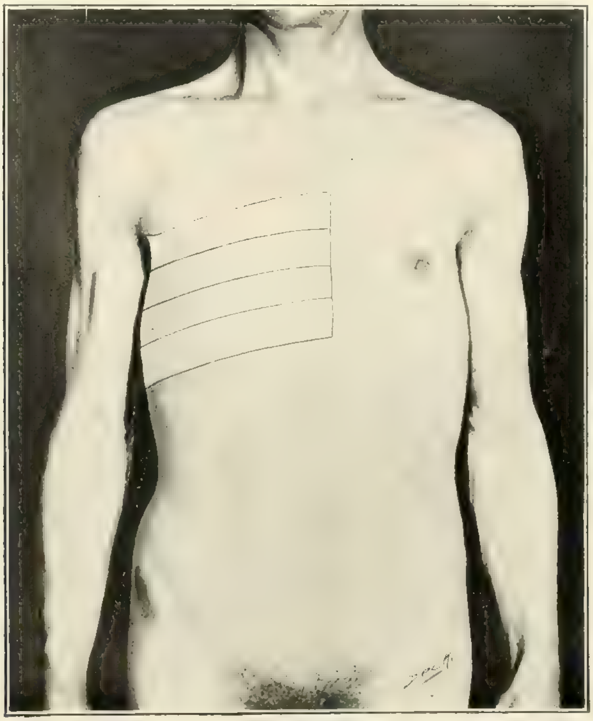

FIG. 382.—Adhesive-Plaster Strapping to Immobilize One Side of the Chest.

Application of Martin's India-Rubber Bandage.—This bandage is three inches wide and four yards long. To its terminal extremity is fastened a double tape for the purpose of securing the bandage after it has been applied. This is chiefly used in varicose conditions of the lower extremity. A turn may be first made about the ankle. The bandage is carried to the base of the toes, and a circular turn is made there. The limb is ascended by spiral turns, the bandage ending just below the knee. Reverse turns are not necessary, as the elasticity of the bandage allows it to conform to the shape of the extremity. In the case of very muscular subjects, however, it may be necessary to use long figure-of-8 turns in order to make the bandage lie smoothly. Even pressure should be exerted from the base of the toes to the knee. The bandage is secured by tying around the limb the two tapes which are attached to its distal end. Such a bandage is removed at night, rinsed with warm water, dried with a towel, and hung loosely over a line to air. The skin of the limb may be kept in good condition by massaging night and morning with alcohol. If, in spite of this, a tendency to an eczematous condition exists, due to daily contact of the rubber with the skin, a thin flannel bandage may be applied next the skin or the rubber bandage may be applied over a white stocking. For use in the Bier hyperæmia treatment of tuberculous joints, or of infections that have developed in the course of an extremity, a much shorter rubber bandage may be employed, only half a dozen

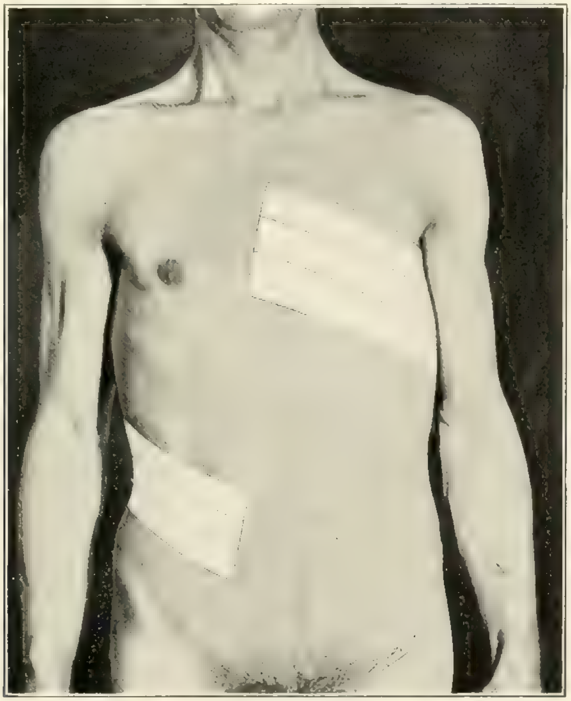

FIG. 383.—Spiral Adhesive-Plaster Strapping of Chest for Fracture of Ribs.

circular turns being used to produce the required hyperæmia. The skin may be protected from irritation by the application of a few turns of a flannel bandage. The parts distal to the area in which it is desired to produce hyperæmia should be supported either by a rubber or by a flannel bandage.

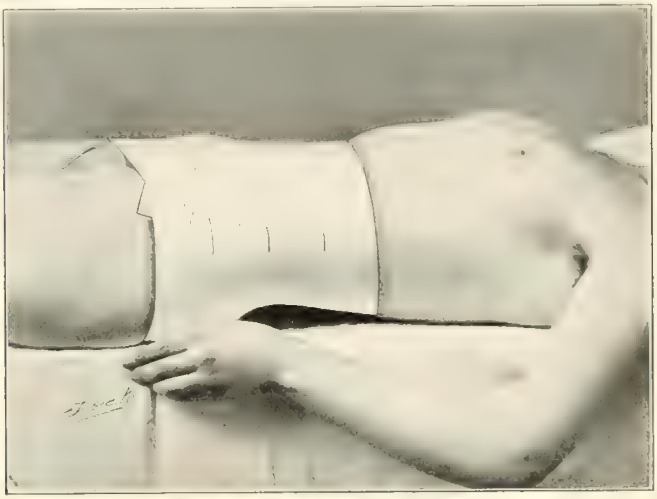

FIG. 384.—Boldt Abdominal Strapping.

EXPLORATORY PUNCTURE; ASPIRATION; HYPODERMIC INJECTION.

Exploratory Puncture.—Exploratory puncture is useful as a means of diagnosis of certain inflammatory conditions and of cysts and tumors. The puncture may be made by means of an aspirator, an exploring needle, or an ordinary hypodermic syringe may be used. For the purpose of securing fragments of the interior of tumors for diagnosis, a special harpoon-pointed instrument has been devised. Whatever the procedure adopted, asepsis must be complete. For purposes of diagnosis in superficial collections, or collections in the neighborhood of joints, the needle should be entered obliquely at some distance from the collection, and then pushed into it.

In case it is desirable to allow a larger amount of the contained fluid to escape than is necessary for diagnosis, a trocar and cannula, or a pointed cannula alone, may be employed. When the puncture is made with the trocar and cannula, the skin should be first incised with a scalpel. While the parts are being steadied by the fingers of the left hand, the trocar and cannula are grasped with the right hand, the index finger of which is held as a guide at the proper point to prevent the trocar penetrating too deeply. By a quick, forcible, stabbing movement the trocar is forced the required depth into the tissues. The trocar is withdrawn and the fluid then flows through the cannula. After the required amount of fluid has flowed out, the thumb is placed over the open end of the cannula, and the cannula is quickly withdrawn. The shape of the trocar and cannula will depend upon the purpose for which it is to be used. A straight trocar and cannula are usually employed, but, in suprapubic puncture of the bladder, a curved instrument is desirable. The size used in a given case will depend upon the character of the fluid to be withdrawn. Should the cannula become blocked, a wire may be passed through it to free its lumen. This may be done while the cannula is still in place. For continued drainage after puncture, special instruments may be devised according to the conformation of the parts.

Exploring Needles are made in several sizes, and should be fitted with a universal thread so that they may be used with an ordinary hypodermic syringe. The same precautions, with the exception of the skin incision, are used in the case of the exploring needle as when the trocar and cannula are employed.

Aspiration.—If this is done for diagnostic purposes it is sufficient to withdraw a hypodermic syringeful of the fluid, but if it is required to empty a cavity a suction apparatus is attached to the exploring needle. Either a Dieulafoy or a Potain apparatus may be used. In the former the fluid is exhausted directly into the barrel of the Dieulafoy syringe, and from thence into a receptacle. In the Potain apparatus the fluid is drawn into a bottle, in which a partial vacuum is produced by the aid of the exhausting syringe. In either event, after the contents of the cavity have been emptied, the suction should be kept up while withdrawing the exploring needle, otherwise infection will be left along the needle track.

Paracentesis of the Pericardium.—Usually the heart, in cases of pericardial effusion, is crowded well back and out of the way, while the pericardium presses forward, producing bulging of the intercostal spaces. By percussion the area of dulness is readily mapped out. The most favorable point for puncture is just above the upper edge of the sixth costal cartilage, near the left lateral edge of the sternum. The exploring needle should be introduced carefully and slowly away from the apex. As soon as fluid ceases to flow, the needle should be withdrawn, and the entrance of air avoided.

Paracentesis Thoracis.—In large effusions the intercostal spaces are usually prominent and the puncture is easily made. The index finger of the left hand is pressed in the intercostal space selected (usually one just below and in a line with the angle of the scapula), and the point of the needle is brought in contact with the skin and at right angles to the ribs. The pressure of the finger in the intercostal space in the neighborhood of the needle-point prevents deviation of the needle if the patient should involuntarily move as the needle enters the skin. If this is not done, involuntary movement of the patient may cause the point of the needle to strike a rib. Guarded by the forefinger lying along the needle the latter is thrust quickly into the chest for the required distance. If, by reason of the physical signs, a point for puncture is selected lower than the angle of the scapula—say, in the ninth or tenth intercostal space—the point of the needle should be directed obliquely upward in order to avoid injury to the diaphragm. In any event the point of the needle should first enter the chest close to the upper edge of a rib in order to avoid the intercostal artery. If it is desired to remove all of the fluid, this should be done slowly; otherwise circulatory disturbances may ensue as a result of the rapid relief of pressure on the heart and large vessels. These precautions are particularly necessary in left-sided effusions.

Paracentesis Abdominis.—In general ascites the site selected for puncture is in the linea alba, half way between the umbilicus and the pubes. The bladder should be empty and the patient should be placed in a semi-sitting posture. Percussion will show dulness from the symphysis upward toward the umbilicus, and tympany above, the dulness representing the fluid, and the tympany the intestines floating above. A Scultetus bandage should be passed around the body, the ends of the corresponding tails of the bandage being held in place by the first half of a knot. The previously sterilized skin is incised with a scalpel, and a straight trocar and cannula are pushed forcibly and quickly into the adominal cavity. The trocar is withdrawn, and, as the fluid flows from the cannula, it is caught in a suitable vessel. As the abdomen decreases in size the tails of the Scultetus bandage are drawn together, and, when the fluid ceases to flow from the cannula, this is withdrawn and the Scultetus is pinned in the usual manner. The fluid should not be too quickly removed. The Scultetus bandage serves two purposes: it causes an even flow of the fluid, and, by combating the loss of intra-abdominal pressure caused by the withdrawal of the fluid, prevents syncope.

Lumbar Puncture.—This subject has already been discussed in detail on a previous page (p. 259 of this volume), and nothing further need be said in this place.

Hypodermic Injection.—The older forms of hypodermic syringes were made with a hard-rubber or glass barrel and a leather-faced piston. Such syringes cannot be efficiently sterilized. At the present time the best hypodermic syringes are made with glass or metal barrels and solid-metal pistons. Colin, of Paris, manufactures such syringes. They are superior to any other form. A less expensive syringe is made by using a glass piston, either solid or packed with asbestos. Needles are of various lengths and diameters, according to the purpose for which they are to be used. For injecting a thin solution into the subcutaneous tissue, a short, slender needle is used; for injecting ergotol and thick solutions, a heavier and longer needle should be employed; for injecting or washing out sinuses, a flexible, blunt-pointed needle, with a larger calibre, should be used.

Hypodermic syringes and needles should be kept scrupulously clean. They should be washed and boiled and dried after each using, and again boiled just previous to using. The needles should have wires kept in them when not in use. Solid-piston syringes should have their pistons withdrawn when not in use. Syringes having leather-faced pistons should have the cap placed on the end of the barrel when not in use, in order that the leather facing may not dry out. A drop of glycerin or a little vaseline may be drawn into the barrel of such a syringe with good effect.

Hypodermic solutions are preferably freshly prepared. If the solution is to be kept for any length of time, there should be added to it a minute quantity of carbolic acid to prevent germ and fungus growth.

The needle and syringe having been sterilized, the required dose of the medication to be injected is drawn into the syringe. In a perfectly acting syringe this can be done with the needle attached. The skin through which the needle is to pass is disinfected by rubbing it smartly with alcohol and a sterile bit of gauze. The usual sites for injection are the outer surface of the deltoid, the outer surface of the thigh, the gluteal region, and the calf of the leg. The gluteal region is usually chosen for such drugs as are not absorbed quickly—*e.g.*, a strong solution of mercury. A strong alcoholic solution should never be used in the subcutaneous tissues, except in the case of nævi, as sloughing is likely to result. Brandy and whiskey should always be diluted one-half before they are used. The skin over the site to be injected is either pinched up, in case the injection is to be made into the cellular tissue, or held tense in case a deep injection is intended. The needle is plunged quickly in an oblique direction to the required depth and the injection is made slowly. The needle is then quickly withdrawn and the site is gently massaged with alcohol on a sterile bit of gauze, to cause diffusion of the injected fluid.

VACCINATION, CUPPING, VENESECTION, TRANSFUSION, HYPODERMOCLYSIS, AND OTHER MINOR SURGICAL PROCEDURES.

Vaccination.—The usual site for this procedure is on the left arm, over the lower portion of the deltoid. In females the vacination may be done on the outer surface of the thigh, or on the surface of the calf, in order to avoid a visible scar.

In vaccinating, the rules of asepsis are to be thoroughly carried out. The skin thus prepared may be either scarified with an aseptic knife, the side of the point of the knife being used to make criss-cross incisions, or these incisions may be made with the ivory point accompanying the vacine virus or, better yet, by a cambric needle. The ivory point and virus are aseptically prepared by the manufacturer. When these incisions are made, care should be used not to cause blood to flow freely, but rather, by a scraping motion, to cause the flow of serum. The vacine virus is well rubbed in, and the abraded surface is allowed to dry. A shield should be applied to protect the parts from irritation from the clothes. This shield should be transparent to allow of inspection of the parts, and should be perforated so that the parts may be kept ventilated.

Scarification.—Scarification is employed for the relief of local congestion. It consists in small parallel incisions made in the skin or mucous membrane over the congested area. In the case of the skin, these small incisions should be made parallel with the normal lines of cleavage of the skin. The procedure may be employed with benefit in inflammatory infections of the tonsils, uvula, and pharynx, particularly when œdema of the glottis is threatened.

Acupuncture.—Acupuncture may be employed in œdema of various parts of the body, to relieve painful swellings, and to allow of the flow of serum from structures beneath the skin. A narrow-bladed bistoury is thrust deeply into the swollen area. One or a number of such punctures may be made, care being taken to avoid important blood-vessels or nerves. The incisions or punctures should be made and treated aseptically, since infection under these conditions is apt to be severe and destructive. To encourage oozing, warm, moist dressings may be used.

Cupping.—Wet or dry cupping may be used. Wet cupping, formerly much employed, is rarely used at the present time. Dry cupping consists in causing a local congestion by applying, over the area where it is wished to produce congestion, a receiver from which the air has been exhausted. Ordinary glass tumblers serve as well as special cupping glasses. The interior of the tumbler is moistened with a little alcohol or proof whiskey. To do this, twist some cotton around the end of a lead pencil, moisten it with alcohol and rapidly smear the interior of the tumbler with the alcohol. Light the alcohol in the tumbler with a match, and apply the tumbler quickly to the area indicated. The stick armed with cotton that has been saturated with alcohol, and the supply of alcohol that was used for saturating the cotton mop, should be kept at a distance from the patient. Care should be taken not to smear the interior of the tumbler too profusely with alcohol; otherwise some may run down over the edge of the tumbler and burn the patient. Several of these tumblers may be used. As the expanded air in the tumbler cools, the underlying soft parts will be forced by the outside atmospheric pressure up into the tumbler, and so congestion of these parts will be produced. The amount of congestion will vary somewhat with the length of time (usually a few minutes) the tumbler is left in place. To remove the tumbler press the skin down with the thumb at the edge of the glass and so allow the air to enter: the tumbler may then be readily removed. Glasses with sharp edges should not be employed, as they may cut the tissues if left long in position. If wet cupping is employed, the above procedure should be first carried out, and then the congested area may be scarified, preferably with a scalpel. (In former times a spring scarificator was employed, but it was found practically impossible to keep the blades aseptic.) The cups are then applied a second time, and the suction from the cups causes blood to flow from the scarified area. When sufficient blood has been drawn, the cups are removed and an aseptic dressing is applied.

The Employment of Leeches.—Leeches are still occasionally used, more particularly by ear specialists for reducing congestion over the mastoid, although Bier's method has superseded their use to some extent. A small puncture is made with a scalpel, and the leech is applied to this. One or several leeches may be applied to a part. After they have served their purpose, if they do not drop off readily or are not easily removed, sprinkling a little salt over them will cause them to let go.

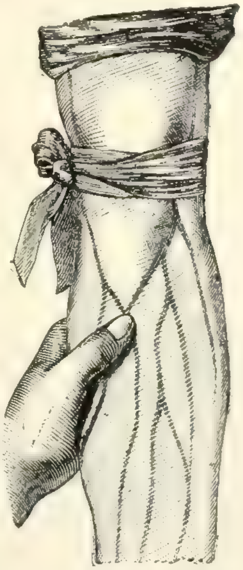

Fig. 385.—Forearm with Fillet Applied. Thumb at junction of median basilic and median cephalic veins.

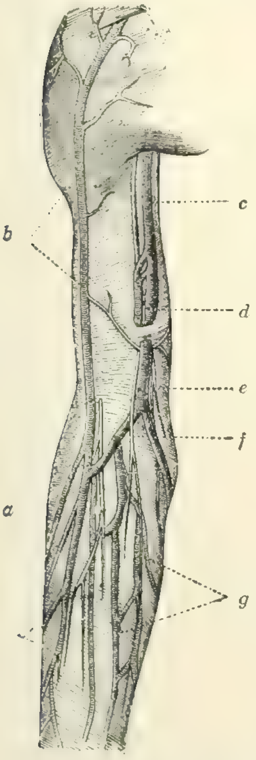

Fig. 386.—The Superficial Veins of the Forearm, the Skin Having been Removed. *a*, Median cephalic; *b*, cephalic; *c*, brachial; *e*, basilic; *f*, median basilic; *g*, anterior ulnar; *d*, median nerve.

Venesection.—This procedure may be indicated in cases in which it is desirable to reduce blood pressure and in cases in which toxins are present in excess in the blood or in which the condition of the blood itself is such as to be poisonous—as, for example, in poisoning by illuminating gas. In both the latter conditions venesection usually precedes direct transfusion of blood from one individual to another. In the experiments of Crile, blood-letting formed a part of the treatment in connection with direct transfusion of blood, and the highest percentage of recoveries was secured when these two features were combined.

Technique.—When the venesection is done in connection with direct transfusion of blood from artery to vein, the blood should be withdrawn from the vein of the patient at the site at which the transfusion is to be made, and this prior withdrawal of blood from the patient's vein should be considered an important part of that procedure. Any of the superficial veins of the arm (Fig. 385) of sufficient size to be utilized in establishing an anastomosis with the radial artery of the donor may be selected. Septic phlebitis, which was dreaded by the phlebotomists of the past century, should not occur under present-day asepsis.

When phlebotomy is done for the purpose of lowering blood pressure, the technique is as follows:—A vein, preferably the median cephalic, is selected and made prominent by a fillet fastened about the middle of the arm. (Fig. 386.) All aseptic precautions are to be employed. The distended vein is steadied by the thumb of the left hand, and with a sharp-pointed bistoury it is opened obliquely to its long axis. A sufficient amount of blood having been withdrawn to lower the blood pressure to the required point, as indicated by the sphygmomanometer applied to the other arm, the fillet is removed, and further bleeding from the vein stopped by the pressure of an aseptic pad of gauze held in place by a figure-of-8 bandage. The arm should subsequently be kept quiet. It should be borne in mind that the more rapidly the blood is withdrawn the more immediate will be the effect on the circulation, and the less will be the quantity of blood necessarily lost.

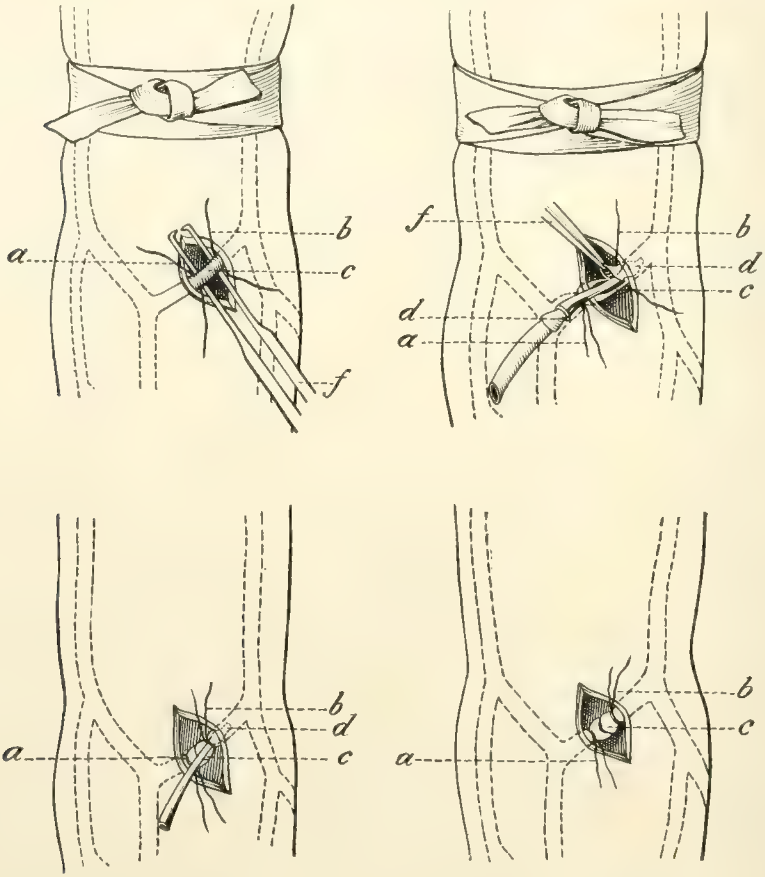

Fig. 387.—Intravenous Saline Injection. Upper left-hand figure—vein dissected and ligatures in position: *a*, Distal ligature; *b*, proximal ligature; *c*, vein; *f*, forceps. Upper right-hand figure—cannula introduced into vein: *c*, Distal ligature tied; *d*, cannula. Lower left-hand figure: Cannula held by proximal ligature. Lower right-hand figure: Cannula withdrawn and proximal ligature tied. (After Ashton.)

Intravenous Infusion of a Saline or an Adrenalin Solution.—The median basilic or the median cephalic vein at the base of the elbow is usually selected for this purpose. A constricting bandage (the fillet) is placed around the upper part of the arm so as to obstruct the return flow through the superficial vein. With aseptic precautions the vein is bared and cleared for a distance of about one inch. Two ligatures are passed around it, one above the point of intended opening, and one below. (Fig. 387.) An opening small and valve-shaped is made in the vein with pointed scissors, and the tube of the cannula is introduced therein, some of the infusion fluid being first allowed to flow through it in order to guard against the entrance of air. The upper ligature is now tightened around the cannula, thus holding it in place and also preventing leakage. The lower ligature is tied in such a manner as to close the vein below. The fillet is now removed. The jar containing the infusion should be lifted about three feet above the vein. The rapidity of the flow of the solution can be regulated by raising or lowering the jar which contains it, or by compressing part of the circumference of the tubing with an artery clamp in such a manner as to narrow the lumen of the tube.

(For further details regarding the strength and quantity of the solutions to be used, the proper temperature of the fluid, the kind of needle to employ, and other technical matters, the reader is referred to the article on Surgical Shock in Vol. I., the section devoted to Treatment, p. 493 *et seq.*)

In cases in which secondary hemorrhage is feared, care should be taken not to raise the blood pressure too high by introducing a large amount of saline. The solution should be allowed to flow in very slowly. In shock, it may be thought desirable by some to combine small doses of strychnia with the saline infusion. This may be done by introducing the hypodermic needle into the rubber tubing and slowly injecting the strychnia into the saline as it passes into the circulation. Adrenalin chloride in 1:1,000 solution may be injected in this manner and may be repeated at brief intervals until the blood pressure is manifestly raised. In cases of shock in which strychnia has been administered before the saline infusion is started, there is always a risk that the saline infusion will cause the strychnia to be absorbed too rapidly. In such cases symptoms of strychnia poisoning may develop. (See also, in regard to the use of strychnia in shock, p. 494 of Vol. I.)

Direct Transfusion of Blood.—Dr. George W. Crile, of Cleveland, Ohio, has recently published* a detailed description of the manner in which this procedure should be carried out, and we believe it better to furnish here rather full extracts from this account than to publish a mere résumé.

Transfusion from a Peripheral Artery of Donor to a Proximal Vein of Recipient.—The question of clotting at the site of anastomosis was eliminated by the use of a mechanical device of Dr. S. J. Mixter's. The present instrument is made by J. C. Ulmer & Co., of Cleveland, Ohio. By means of this tube anastomosis may be made so that intima is in contact with intima alone, without damage to this structure and without the possibility of any foreign body coming in contact with the blood stream. In clinical transfusions we have utilized the radial artery of donor and any superficial vein of the recipient. Give both donor and recipient a hypodermic injection of morphine twenty minutes before transfusion, before they enter the operating-room. After their arms are prepared, a nurse places a wet towel over their eyes with the explanation that the eyes must be protected to prevent headache. Donor is placed on an operating-table of the Trendelenburg type so that in case he should faint he can be readily lowered. Recipient is also placed on an operating-table with his head in an opposite direction from the donor. By the use of an infiltration anæsthesia of one-tenth-per-cent solution of cocaine, about 3 cm. of the radial artery is exposed and the smaller branches tied with pieces of very fine silk; a "Crile" clamp is applied to the proximal end of the artery and the distal end is ligated; the artery is then divided; the adventitia is pulled over the free end as far as possible and snipped off close; a moist saline sponge now covers this field; 3 or 4 cm. of the superficial vein of the recipient is then freed, the distal part ligated, the proximal closed with the "Crile" clamp; the distal part then is divided with the scissors, the adventitia drawn out as far as possible and snipped off close; the vessels are then inspected and a cannula whose bore is larger than the actual tissue thickness of either vein or artery is selected. The vein may then be pushed through this tube, after which the free end is turned back like a cuff and snugly tied in the second groove. During this time the handle of the cannula is steadied and manipulated by means of forceps. If the artery is atheromatous, and therefore firmly contracted, or if for any other reason contracted or quite small, its lumen may be dilated by means of a mosquito hæmostat pushed into the lumen, then opened gradually. The artery is then drawn over the vein and is snugly tied with a small linen ligature in the first groove. This completes the anastomosis. The clamp is then removed from the vein, afterward gradually from the artery, when the blood stream will be seen to pass from the artery across to the vein, dilating the latter. However, the exposure and manipulation of the vessels cause them to retract, particularly so in the case of the artery. This vessel may contract so firmly as to obliterate its lumen. The constant application of warm saline solution and protecting it from the air will help materially in bringing about relaxation and, hence, a free stream of blood. The pulse wave may be palpated in the vein. It it best to introduce the blood very slowly, watching carefully the result. In some instances, when the stream passed over under too great a head and when the cardiac muscle of the recipient was weak, symptoms of acute dilatation occurred. There was precardial distress, pain extending through to the back, and almost incessant coughing, rapid pulse, and considerable cyanosis. These symptoms in each instance passed off after a time, though when once they developed they seriously hampered the transfusion and diminished the quantity of blood that might with safety be transferred. In the majority of instances we have been able to transfer the blood without the patient's knowing that it was done, thereby entirely avoiding the psychical factor. In cases transfused for profound shock or hemorrhage, the transformation of the face is a most striking phenomenon, consisting of a gradual obliteration of the pale, haggard facies and a substitution of a fuller, more rounded, pink coloration of glowing health. Not only is there transformation in the facies, but also in the psychical state and in the general well-being of the patient. In the donor, after from twenty to forty-five minutes of continuous flow from the radial artery in a good anastomosis, a gradual pallor of the extreme points, viz., the nose, ears, etc., may be noted, and more serious effects of the loss of blood will be observed if the transfusion is allowed to go on. The transfusion should, therefore, be terminated as soon as the donor shows irregular respiration or sighs, is a bit uneasy, or presents a characteristic facies. The earliest and most constant change noted in the recipient is the almost instant and continuous rise in the blood pressure, continuing up to a certain point, the total rise depending upon the physical state and the quantity of blood transfused. There is also a rise in hæmoglobin and the red count. The most constant phenomenon on the part of the donor is the rise in the leucocytes.

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*The Canada Lancet, August, 1907, vol. xl., pp. 1057–1068.

Hypodermoclysis.—In cases of a less urgent character hypodermoclysis may be substituted for intravenous saline infusion. The apparatus consists of a hollow needle, an irrigator, rubber tubing, and an ordinary bulb syringe. The needle is introduced into the cellular tissues beneath either breast, and from one to two pints of the solution is slowly introduced, usually a pint beneath each breast. This is rapidly absorbed. Should a second hypodermoclysis be indicated, it may be given in the interscapular region or on the inner surface of the thigh.

Auto-transfusion.—Auto-transfusion, like intravenous saline infusion, should be employed only after the source of the hemorrhage is under control. In cases of shock it is used to favor the cardiac and respiratory centres in the medulla. In such cases the foot of the bed is raised to an angle of forty-five degrees. This tends to force the blood to the medulla. In some cases of hemorrhage one or all of the extremities may be bandaged, beginning at the most distal point and bandaging toward the trunk, thus forcing the blood of the extremities into the body. This is of great value as a temporary resource. It does not take the place of intravenous saline infusion, but may be used to gain time and tide the patient over while the saline infusion is being prepared. The extremities should not be kept bandaged in this manner for longer than two hours.

PLASTIC SURGERY.

By JAMES S. STONE, M.D., Boston, Massachusetts.

GENERAL CONSIDERATIONS.

Plastic or reparative surgery deals with the correction of deformities involving chiefly or primarily the skin or soft parts rather than the bones, ligaments, and tendons. While no definite line can be drawn between plastic and orthopedic surgery, yet custom has to a great extent marked out the field of plastic work.

Although it is one of the oldest branches of surgery, nevertheless of recent years the attention which has been given to abdominal and other work has to a certain extent diverted interest from many reparative operations, which are of the utmost practical importance. Only a comparatively minor part of plastic surgery is undertaken for cosmetic reasons. A thorough understanding of plastic surgery may often, for example, enable the surgeon to remove from the face malignant tumors which otherwise he might regard as being inoperable. A knowledge of the resources at his command will often, in the case of a workingman, lead the surgeon to save the fingers or the hand which would otherwise be amputated. In no branch of surgery is there greater opportunity for originality than in this. In fact, no branch compels originality and puts to the test the resources of the surgeon more than plastic work, and this makes it fascinating. Fortunately, in almost all cases the operation can be, and whenever possible ought to be, planned beforehand with the utmost attention to every detail. All possible contingencies should be foreseen, and the course to be followed in any event should be clearly planned before prognosis is given or a cut is made. A failure at the outset frequently makes a later success much more difficult and often impossible.

Plastic operations should be attempted only under certain definite conditions. The patient should be in good general health and the parts of the body concerned in a suitable state for the purpose. Also the environment and outfit should be in keeping with the attempt. These conditions being fulfilled, success will depend on minute attention to the numerous details.

GENERAL PRINCIPLES OF PLASTIC OPERATIONS.

The general principles of plastic operations may be enumerated at once.

Accurate apposition minimizes scar tissue, and thus prevents secondary contractions. Therefore prompt and firm union of refreshed surfaces is essential.

Sound tissues only should be utilized. Scar tissue or diseased tissue should not be used when it is possible to avoid it. Pale, glossy cicatricial tissue is particularly to be avoided. Cicatricial tissue at the base of a flap or running across a flap is peculiarly liable to cause sloughing because of interference with proper nutrition. Cicatricial tissue should never be left at the edge of a flap, because healing of this tissue is extremely slow and unsatisfactory; and when it is thus located, no trust should be placed in its reparative powers.

The flaps used in plastic operations invariably shrink, and therefore should be cut a third to a fourth larger than the area which it is intended they should fill. The shrinkage varies with the direction of the elastic fibres. Flaps should include enough vessels and subcutaneous tissue to maintain their nutrition. It is of great advantage to include a main artery in the pedicle. The distribution of nerves is of less importance. The least possible tension (preferably none at all) should be made upon flaps, and all flaps should be handled and sutured with the greatest care. Therefore the pinching of flaps by forceps should be avoided; and instead tenacula should be employed to draw them into position. The sutures should be so placed that tension is evenly distributed. Tension should never be put upon the pedicle of a flap. A flap should never be left blanched at the end of an operation. If so left, it will slough with absolute certainty.

Asepsis rather than antisepsis should be the aim, both at the time of operation and during the convalescence. Vigorous scrubbing is to be avoided, since it objectionably arouses the circulation and the "stitch-abscess" germs of the skin.

Hemorrhage should be stopped before the flaps are sutured.

Not only should the part be immobilized, but soft and unirritating dressings should be applied so as not to interfere with the nutrition of the flaps. In cases of doubt regarding the vitality of a flap, prompt inspection should reveal the progress of repair, and, in instances of impending death of the flap, it should be released and even restored to the original sites, thus perhaps rescuing the patient from additional disfigurement.

The needles, sutures, and manner of tying are matters of great importance, especially in plastic surgery. The needles are curved or straight as may be desired; usually the former are the more convenient. They may be round or angular, the latter having one or more cutting edges. Those with cutting edges enter the tissues more easily, the round being often difficult to pass and requiring care, as otherwise the flaps will be unduly handled. The cutting edge of a needle should be on the convex surface, not at the concave, and never at the external borders. In the last instance bleeding is encouraged and a too large stitch hole is made, which is caused to gape when the suture is tied (Fig. 388, *A* and *B*), thus laying the foundation for infection and disfigurement. The puncture made by the round needle holds a ligature the best with the least danger of disfigurement. That made by a convexly curved cutting border is next in order of efficiency, the one made by a concave cutting border holds a suture well, and the last two are closed when the suture is tied. (Fig. 388, *C* and *D*.)

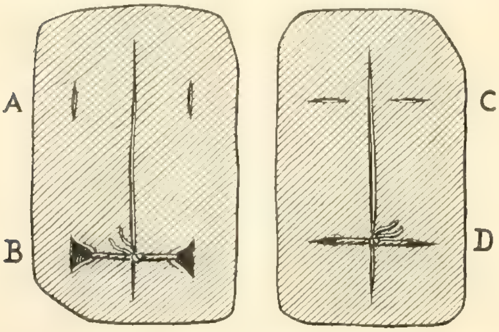

FIG. 388.—Variety of Needle Holes. *A* shows the holes made by a needle with the cutting edges at the sides. The long diameter of the holes is parallel with the cut in the skin; *B* shows the effect of tying the suture. The holes are made to gape by the pull of the suture upon the sides. Thus bleeding is favored and an entrance for infection is left open; *C* shows the holes made by a needle with the cutting edge on the concave or convex borders. The long diameter of the holes is at right angles to the skin incision; *D* shows how the holes are not opened by tying the sutures. (After Pozzi.)

Chromicized catgut, horsehair, silkworm gut, silk, linen, and also silver wire are accepted agents for suturing in plastic work. Horsehair will stand but little traction and therefore is useful when little or none is needed. Silkworm gut is often the best agent for the purpose. It is nonabsorbent, strong, coarse or fine, and a single fold of a knot, the ends lying flat, will usually suffice to hold the borders in proper apposition. Silk makes a good suture and is of almost universal application. The advantage of silk is its great pliability; the chief objection is the capillary meshwork along which infection may spread. The celluloid linen stitches are to a great extent free from this objection. Catgut should not be used about the mouth or where it may become unduly moistened. Fine silver wire is a serviceable agent, but is employed much less frequently. Of whatever material it may consist, the suture should only bring the borders of the wound in close contact with each other, allowing of opportunity for swelling without the danger of strangulation of the included tissue, which is so provocative of ulceration and disfigurement. No suture should ever be sufficiently tight to exsanguinate the tissue within its grasp.

Whenever stitch abscesses seem imminent it is better to introduce new sutures near to hand than to rely on the first, which should then be removed. In the removal of silkworm-gut sutures and those of a similar nature they should be cut at one side close to the skin and be unhooked, as it were, for apparent reasons.

There are several methods of practice in reparative work, but direct union of the edges of a defect is the simplest procedure of all. The parts may be united by sliding or lateral displacement of the edges of a defect. This is known as the French method. Or flaps may be taken from parts in the immediate neighborhood and transferred to the location of the defect, the nourishment of these flaps being furnished by a pedicle containing sufficient blood supply. This is known as the Indian method, and has been practised for centuries. The flaps may also be taken from distant parts of the body, a procedure known as the Italian method or that of Tagliacozzi, because first described in his work "De Curtorum Chirurgia per Insitionem," published in 1597. Another method is by the use of grafts.

In addition to these methods by operation, prosthetic means are often required to supply irremediable defects.

Direct union of the sides of a defect can be accomplished only by thorough refreshing of the edges to be apposed. This should be done with a sharp knife rather than with scissors. Cuts through the skin or the mucous membrane should always be made at right angles to the surface except in the case of the hairy scalp. Incisions in this locality should be made at such an angle as not to cut across the roots of the hairs; for, if their slanting roots are cut across, then, after union of the edges of the wound has occurred, a small bald spot will be left in the area which would otherwise have been covered by these hairs.

In those cases in which tension is too great for satisfactory union, much freedom may be gained by undermining at the sides of the opening. Undermining should be done with a knife and should include all the subcutaneous tissue down to the fascia, except in those instances where important structures might be injured, as, for example, the branches of the facial nerve in operations on the cheek. In operations intended to fill large gaps, undermining should be practised unsparingly. A surprising amount of freedom of motion is gained for the tissues thus treated, and tension is correspondingly diminished. When the fascia is divided, care should be taken to secure the union of its cut edges. The importance of this will be appreciated when it is remembered that the fascia supports the skin, and that consequently the withdrawal of this support will surely cause the scar in the skin to stretch. On the other hand, if the edges of the fascia become firmly united, the scar in the skin will stretch only when the tension is unusual.

In suturing the edges of a gap, it is often unwise to use a subcutaneous stitch if there is much tension. Where such tension exists, apposition can be obtained more perfectly by other methods of suture, and accuracy of apposition is of great importance in preventing spreading of a scar. The marks of stitch holes are usually less objectionable than a broad scar. A subcutaneous suture may be used, provided that the fascia is united below so securely as to prevent tension, or provided that other sutures are passed in such a way as to prevent tension disfigurement.

In those cases in which direct union is impossible, even after extensive undermining of the edges of the gap, lateral incisions may be made parallel with and somewhat removed from the gap, thus allowing greater mobility of the edges and substituting two narrow defects for one wide defect.

DIFFERENT METHODS OF FILLING IN GAPS IN THE SKIN.

Flap Formation.—In plastic operations upon those portions of the body in which tension does no particular harm, the filling of gaps by the French method of sliding flaps in from the sides is almost always that of choice. For example, after the removal of any tumor of the abdominal wall, or after the removal of the breast, the defect had best be filled, as far as is possible, by sliding in flaps of skin from the edges. This method, however, is usually very unsatisfactory in those instances in which tension is to be avoided. Thus, for example, in restoring the border of any orifice (a lip or an eyelid), or in closing a defect in the palm or the flexor surface of the elbow or the knee, the use of a flap slid in from the borders of the gap may often be followed by relapse unless the flap is so planned as to guard against this result. It is therefore essential that tension must never be so great as to perpetuate a deformity.

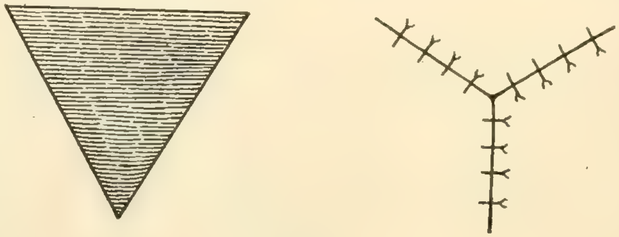

Fig. 389.

The Indian operations, in which flaps are connected with their bases by a relatively small pedicle, usually so change the direction of the flap that any tension is entirely transferred away from the original to the secondary gap. The flaps are, moreover, usually jumped across areas of undisturbed skin, so that the tendency to retract is lessened.

The various types of the French and Indian methods of flap formation should be thoroughly understood.*

Small triangular gaps may be closed by direct suture of the sides, the work beginning at each angle and terminating toward the centre. (Fig. 389.) A larger triangular gap may be remedied by freeing one or both of the longest sides.

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* In many illustrations in this article letters are used. The intention is to make more plain the manner in which flaps are transferred. Corresponding points on different sides are often given corresponding letters (*e.g.*, A and A') if these points are later to be united. The tip of a flap may be given a capital letter, and the untouched area adjoining the point from which it was taken may be given the same small letter (*e.g.*, A, A', a, a') if both sides of the body are involved.

This should be done by an incision extending, in one or both directions, the line of the base of the triangle, and undermining the flap or flaps thus marked out. (Fig. 390.) The objection to this procedure is that the tension at one side of the base of the triangle is apt to be greater than at the other, thus puckering the skin at one or both sides of the gap. To obviate this difficulty, Burow suggested the excision of two smaller triangular areas, each one-fourth the size of the original gap, on the opposite sides of, and just beyond, the base of the original defect. (Fig. 391.) This method equalizes tension by removing redundant skin, but the objection to it is that sound skin is sacrificed and additional lines of scar are created. It should be remembered, however, that in time redundant tissues always tend to flatten and contract, and that this tendency therefore aids in lessening deformity. Instead of carrying the incisions in opposite directions along the line of the base of the triangle, it is usually preferable to curve them slightly toward the sides of the gap. (Fig. 392.) In this manner not only may the lines of the features be followed and scars thus be hidden, but important structures can readily be avoided and, more significant still, the distribution of tension is made more even and the tendency to redundancy is lessened.

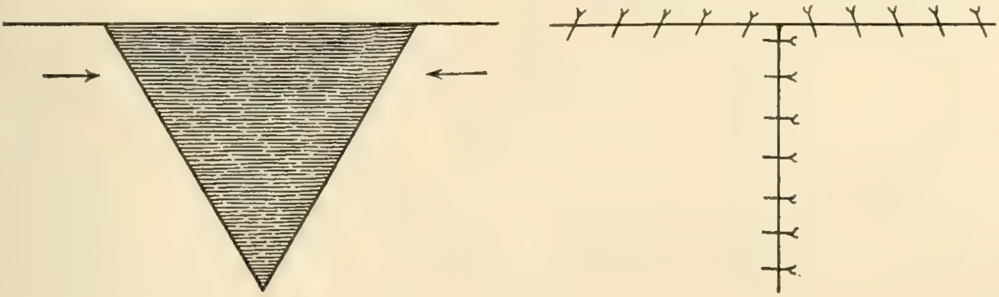


Fig. 390.

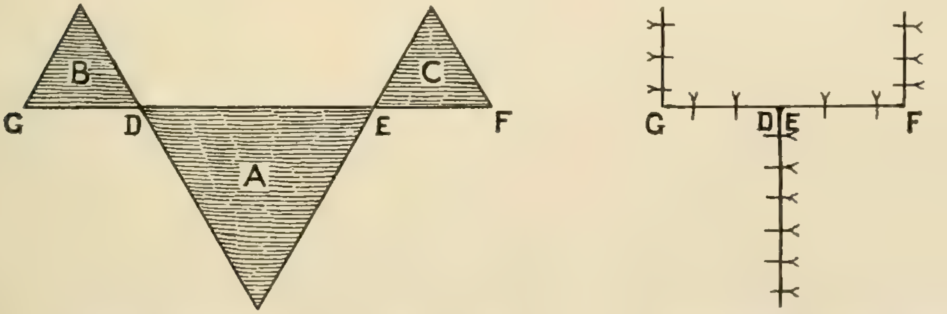


Fig. 391.—Burow's Method of Closing a Triangular Gap (*A*) by Excising the Smaller Triangular Areas (*B* and *C*) and Mobilizing and Uniting the Flaps (*D* and *E*). The secondary flaps (*F* and *G*) must also be mobilized and drawn inward.

Dieffenbach closed one triangular gap by the creation of another of equal extent in a different location. The short side of the triangle is directly extended by an incision as far as may be desired. Then the incision is turned sharply downward in a direction parallel with the nearest side of the triangle until three sides of a parallelogram are formed. The flap thus marked out is freed by dissection and is slid into the original gap, leaving one of a secondary kind. (Fig. 393.)

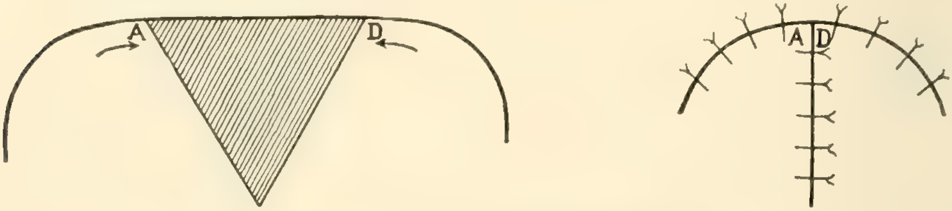


Fig. 392.—Jaesche's Method of Curving the Incisions which Free the Flaps, in Order to Equalize Tension.

By curving the upper line of incision, as in the Jaesche operation (Fig. 392), the secondary gap may be made smaller.

A quadrilateral gap may be closed by extending either or both of two opposite sides by incisions carried in one or both directions. The flaps thus marked out and freed may be brought together and sutured. (Fig. 394.)

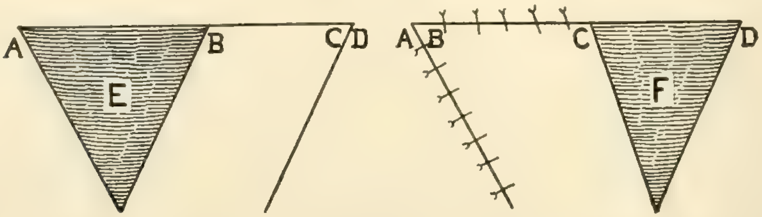
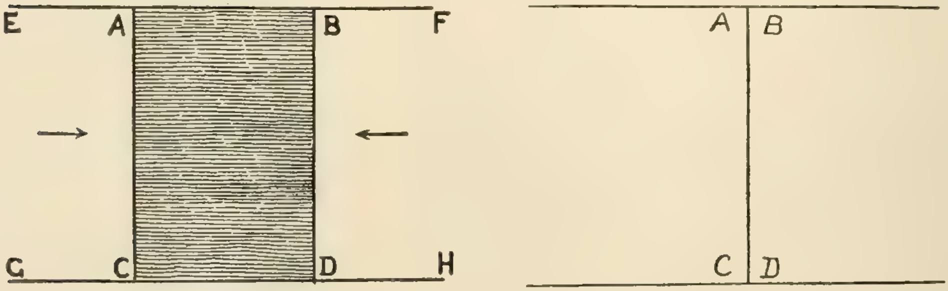


Fig. 393.—Method of Closing the Gap *E* by Creating the Gap *F* in a Less Important Place.

Letenneur's operation, although seldom employed for the purpose, is used for closing a quadrilateral defect. A flap from one side is turned in so as to fill the



a *b*

Fig. 394.—The Incisions *A E* and *C G*, and *B F* and *D H* are Made. The Flaps *E A C G* and *F B D H* (shown in *a*) are Undermined in Order to Bring Together the Sides *A C* and *B D* (see *b*).

gap. The pedicle of the flap is curved toward the gap. The diagram (Fig. 395) explains the operation sufficiently.

von Bruns' operation involves an important step, which has not yet been mentioned, viz., the jumping of a pedunculated flap across an area of sound skin, and the permanent fixing of it in a different direction from that which it originally had. For example, in order to close a quadrilateral gap, the following steps should be taken: at each end of the gap there is formed a quadrangular flap, the pedicle of which lies immediately contiguous to the gap, while the free end of the flap extends into the tissues beyond the defect. The two flaps are raised, jumped into the gap, and united in the middle. (Fig. 396.) The operation may, if desired, be modified by making the free ends of the flaps taper to a point, and uniting them one above the other, instead of end to end. In this manner the secondary gaps may be closed more readily.

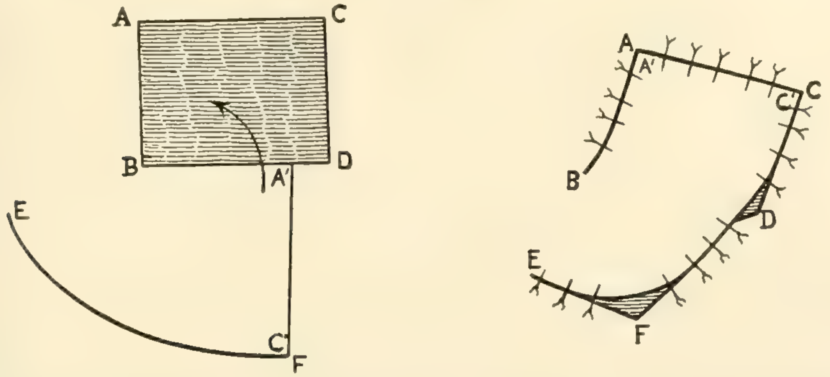


FIG. 395.—Letenneur's Operation. The flap *B A′ C′ E* is swung on the pedicle *B E*. The side *B A′* is to equal the side *A B*. The incision *A′ C′* is to equal the length of the gap *A C*.

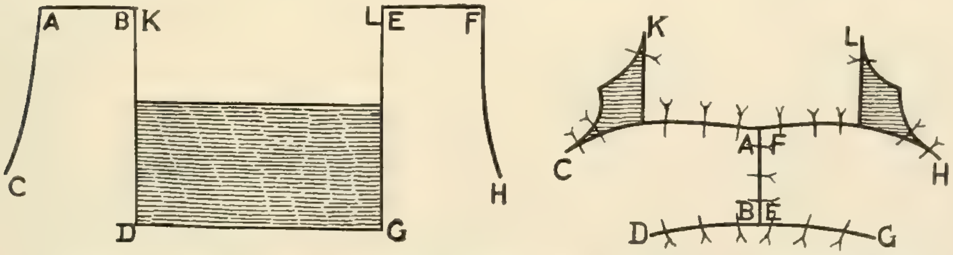


FIG. 396.—von Bruns' Operation. The two diagrams show how the two flaps, united end to end, fill the defect.

The method of drawing two wedge-shaped flaps past each other is often useful, especially in closing elliptical gaps. (Fig. 397.)

An elliptical gap may be closed also by forming two flaps at one side and drawing them into the defect, leaving a wedge-shaped area of skin undisturbed between them. (Fig. 398.)

The Italian method of transferring flaps from distant parts of the body will be described in detail when we come to consider the operations where it proves most useful. The method of double transfer suggested by Shrady should also be mentioned. This method is described by Sir William MacCormac, in his address on plastic surgery (*Birmingham Medical Review*, Vol. XIV., July–December, 1888, p. 241 *et seq.*), in the following words:

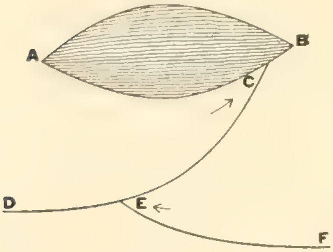


Fig. 397.—Weber's Operation. The elliptical gap *AB* is filled by making two wedge-shaped flaps *ACD* and *CEF*. The point *C* is brought into the angle *B*. The point *E* is then brought into the angle freshly made at *D*.

"In order to fill a most unsightly gap in a girl's cheek, Dr. George F. Shrady, of New York, lately told me of a case in which he had practised the following very ingenious and, so far as I know, quite novel and original method of what may be called the mediate transferrence of a flap of skin from the arm to the cheek, by using a finger as a medium to transport the flap from one position to the other. I am indebted to Dr. Shrady's courtesy for these details, as the case is as yet unpublished:

"The arms are folded in front in such a manner as will allow the hand to rest easily with its palmar aspect against the lower portion of the opposite arm above the elbow; the other hand adapts itself in an easy position beneath the opposite elbow. This position is a comfortable and natural one, and can be well borne for a considerable time, when the limbs are subsequently bound together by plaster-of-Paris bandages. The bearings having been noted, a suitably sized flap is dissected from the outer aspect of the arm, above the margin of the outspread forefinger, the base of the flap downward and the tongue up, or if found more convenient this may be reversed. The skin of the radial margin of the forefinger is then split for a sufficient length to fit the margin of the flap, and the latter, when the hand is in position, is stitched carefully to the split in the finger. This necessitates the curling downward of the flap so that its raw surface presents outward. 'My purpose,' Dr. Shrady writes, 'in curling the flap was to have the skin surface form the lining of the cheek. The presenting raw surface on the cheek was afterward covered by sliding skin flaps from the neighboring parts. In other cases it will be more convenient to have the cutaneous surface presenting externally, and this may be effected by dividing the flap at its inferior extremity. The flap grew nicely to the cheek, and when separated from the finger maintained its vitality. It was allowed to grow, with its upper portion only attached for some time, and then the sides and lower portions (previously free) were stitched into position. As a result of a subsequent operation for covering the granulating surface, the lower portion of the original skin flap sloughed, but enough remained to make a very presentable and useful cheek.' Dr. Shrady thinks the result proves that the principle is a good one. It is easy of

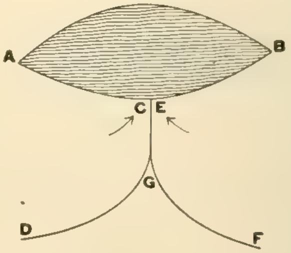


Fig. 398.—The Elliptical Gap *AB* is Closed by Sliding the Flaps as Indicated. It is essential that the point *G* be left undisturbed. The borders *CD* and *EF* are drawn by the point *G* and gain support from it.

application, comfortable for the patient, and establishes the fact that the hand can be used as a means of intermediate transplantation to almost any part of the body within reach."

In 1880 John Croft applied, to the correction of cicatricial contraction after severe burns, a method of flap transfer which had previously been used in treating exstrophy of the bladder.* According to his plan the first operation should consist of the following steps: A bridge of sound skin and subcutaneous tissue is raised from the immediate neighborhood of the deformity. For example, when the cicatrix which it is intended to supplant is located in the neck or at the elbow, the skin, which is to form the bridge, is taken from the back of the neck, from the shoulder or from the arm, at one side of the defect. The bridge is cut as long as practicable and as thick as possible, especially in its central part. The length of the bridge cannot safely be more than three times the width. The ends are left attached, the sides of the wound being approximated by sutures passed underneath the bridge. Oiled silk protective is inserted between the raised skin and the triangular raw surfaces underneath the ends of the bridge, to prevent union between the ends of the flaps and the underlying tissues, for such union would shorten the length of the span.

It is important to keep the parts immovable, for the nutrition of the bridge may be dangerously interfered with through displacement of the dressing. After an interval of two to three weeks the next step in the operation is undertaken. The bed into which the flap is to be transferred is prepared by cutting through the cicatrix down to normal underlying tissues, thus providing a suitable site for the flap. It is essential that this be done thoroughly. Then one end of the bridge is severed. The length of the flap should necessarily conform to the length of the gap to be filled, and a careful estimate (with allowance for shrinkage) should be made. It is less important that the breadth should correspond exactly. The edges of the granulating under surface at the free end are to be pared and freshened so that they will present raw surfaces for primary union with the severed end of the flap.

At first the transplanted flap is apt to look very ungainly, unsightly, and unpromising. During the interval between the first and second operations, however, it becomes narrowed and shortened as well as thicker from the amount of granulation tissue which has developed at the same time. Eventually, however, the sausage-like flap flattens down and spreads out until finally it may become wider than it was originally cut.

The advantages claimed for this plan of operating are that the risks of sloughing are greatly diminished, and that, instead of being transplanted when recently drained of blood and reduced in temperature, the flap is moved when abundantly vascular and warm. These advantages, which enable the operator to proceed with confidence and deliberation, are to be set against the longer time during which the patient remains under treatment. The practice is certainly superior to that of transplanting flaps from a distant part of the body and is of use in those cases in which sufficient skin from distant parts is not available.

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*Medico-chirurgical Transactions, vol. lxxii., 1889, p. 349.

Skin Grafting.—There are three methods of skin grafting in common use, and they are known respectively as the Reverdin, the Wolfe-Krause, and the Thiersch methods.

A. THE REVERDIN METHOD.—Reverdin, in 1869, was the first to describe this form of skin grafts, although substantially his method had been used previously in India. Reverdin's procedure consists in snipping off with a knife or a pair of sharp scissors numerous small bits of skin not over 4 or 5 mm. in diameter, and planting them, deeply or superficially, with the cutaneous side up, in the granulating surface. This method, when the grafts are healthy, gives numerous small cutaneous islands from which new epidermis will spread, and at the same time it will be found that the border of the ulcer responds in a similar manner. Under certain circumstances the method is of great value. It is especially applicable in those cases in which the general condition of the patient is such as to prohibit other more extensive methods of grafting, or in those cases in which the area to be closed is so small that it seems unnecessary to subject the patient to other methods of grafting. It may be also employed when other methods, for various reasons, are not available. Anæsthesia is not required for Reverdin grafting. No special preparation of the surface on which they are to be placed is needed, except to make it as clean and aseptic as possible without causing irritation.

B. THE THIERSCH METHOD.—Thiersch grafting is by far the most generally employed method. The grafts are enormous as compared with those just described. Thiersch grafting usually requires the use of an anæsthetic. General anæsthesia is more satisfactory than local, because, if the latter is not complete, the pain is apt to be exquisite.

Preparation of the Field.—Thiersch grafts are applied to a raw surface—either immediately to a freshly cut surface or to a granulating area. In cases, however, in which they are to be applied to a granulating area, it is advisable to scrape off with a curette, or rub off with a piece of gauze, all the soft granulations, thus exposing the firm base of the ulcer on which the grafts are to be placed. As soon as the granulation tissue has been removed, the bleeding is to be stopped by pressure with hot wet gauze. The surfaces are then to be thoroughly washed with salt solution. Oozing will be found to have ceased entirely by the time the grafts are ready to be applied. The removal of the granulations helps to insure success, largely through the mechanical cleaning of the field.

Cutting the Grafts and the Proper Mode of Applying Them.—The grafts are taken from sound skin belonging to any part of the body, by preference from the thick skin of the anterior and outer aspects of the thigh. The skin should be rendered as aseptic as possible, but no antiseptic should be used at the time of the operation, and care should be taken to wash off any irritating antiseptic which may have been used before the commencement of the operation. The skin from which the graft is taken must be put on the stretch and held as flat as possible. For this purpose McBurney has devised hooks (Fig. 399), which are useful for holding the skin, but are not absolutely essential, since the skin can be stretched satisfactorily by the hands of the assistant and the operator when placed flat on the limb, or, better, by two pieces of thin splint board held against the skin at either side. The superficial epidermis is removed over as large an area as is required. The cutting of the grafts is best done with a very sharp long-bladed knife held loosely like a fiddle bow, and drawn rapidly back and forth across the surface from which the graft is being taken. An ordinary thigh-amputating knife is very satisfactory for the purpose. A razor will answer less satisfactorily because of the shortness of the blade. A microtome knife, though heavy, will answer the purpose when others are not available. Knives specially made for the purpose may be secured of instrument merchants. The removal of the graft is greatly facilitated if the knife and the surface of the skin are kept constantly moist with a fine stream of warm salt solution during the cutting process. As soon as the grafts are removed, they should be immersed in sterile salt solution until a sufficient number have been obtained to cover completely the raw area, and then they should be applied by spreading the grafts, while still in the salt solution, on a small piece of rubber protective tissue. The raw surface should not, of course, be in contact with the rubber. If the rubber is then lifted from the salt solution, the graft will adhere to it, and may then be transferred directly to the denuded area by beginning at the edge and pressing the rubber tissue firmly down against the denuded area, so as to remove the air bubbles from under the graft. This step is of great importance. The rubber tissue may then be carefully rolled back, leaving the graft in position. Other portions of cuticle are to be applied in a similar manner until the whole area is covered. No raw areas are to be left uncovered at the edges or between the grafts. It is better to have two grafts overlap a little than to have an interval left between them. It is of the utmost importance in handling the grafts that no mechanical injury be done to them. They should never be picked up with forceps, but may be lifted with a probe or director. They should be pressed in place firmly with a probe. If all air is pressed out from under a graft, it promptly takes on a pale bluish color, unless it be unduly thick. Bleeding below a graft

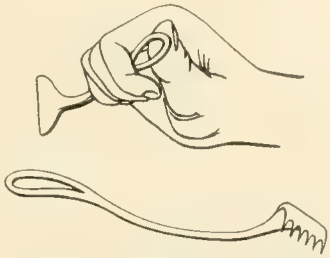
FIG. 399.—McBurney's Hooks are like Rakes with Sharp Teeth which Dig into the Skin and Hold it Tense. (After Fowler.)

inevitably prevents it from adhering at the site of extravasation. It is often easy to transfer the graft directly on the knife to the ulcer.

Dressings.—Various methods of dressing have been devised. Some saturate gauze in normal salt solution and press it down firmly upon the grafts, this primary dressing being left in place for about ten days. Others put a thin rubber tissue between the gauze and the grafts. If this is done, small holes must be cut in the rubber tissue at intervals of at most half an inch, in order to give free vent to any discharge; otherwise the grafts may be macerated by the discharge that accumulates in the wound. The rubber tissue is similar to that used by tailors. As it softens with heat it must be sterilized chemically, but all antiseptics must be washed off before it is applied. By folding the tissue and cutting rows of slits with the points of scissors (Fig. 400) ample drainage may be provided. Either of these methods is perfectly satsifactory. Where the rubber tissue is used, the first dressing may be done a little sooner than otherwise, but it is always advisable to wait eight or ten days before undertaking the first dressing. Another satisfactory dressing is to cover the grafts completely with several layers of tinfoil, and then to put gauze outside. The gauze, which is placed outside the tinfoil or rubber tissue, may be either kept dry or be wet with the salt solution. Most surgeons prefer to have the gauze moist, in order to prevent drying and crusting of the secretions.

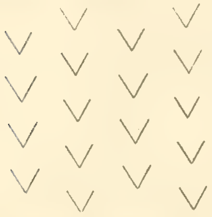
Fig. 400.—Rows of V-Shaped Slits Cut in the Protective Tissue to Allow Escape of any Exudate from the Surface of the Raw Area.

Whatever the dressing may be, nothing is to be gained by early examination of the field unless there are obvious reasons for doing it. Some surgeons advocate the practice of not placing the dressing directly on the grafts themselves. They protect the region mechanically by some form of cage, but otherwise admit the air freely. The choice, in practice, must depend on the individual preference of the surgeon.

The area from which the grafts have been taken is to be dressed with boric-acid ointment or in any other proper manner. It will heal promptly, leaving but trifling scars, unless by chance the knife has passed too deeply into the skin. In that case a permanent cicatrix is left, but otherwise the only sign will be a slight change in the color of the skin.

C. The Wolfe-Krause Method.—J. R. Wolfe (*British Medical Journal,* September 18, 1875, Vol. II., p. 360) first described a method of skin grafting which has since borne his name. His plan is to excise and transplant at one operation a piece including the whole thickness of the skin. Previously, transplanted skin had always remained attached by a pedicle for some days, in order that its nutrition might be assured until it had formed sufficient new connections to establish its life. Wolfe maintained that the pedicle was unnecessary and that it served seriously to limit all efforts at reparative surgery.

The pedicle once eliminated, the surgeon was left free to choose the region from which to remove the flap or graft.

Just as in the Thiersch grafts, asepsis rather than antisepsis should be the aim, and under no circumstances should irritant antiseptics be used during the operation. The graft may be taken from any part of the body. Sometimes the prepuce may be utilized. Allowance of about a third must be made for contraction of the graft after its removal and before application. It is important that the skin should not be bruised and should be handled as little as possible. Trifling injury to the skin is very likely to lead to necrosis. It is essential to success that all the areolar tissue should be removed from the under surface of the graft. The area into which the graft is placed should be clean, free from bleeding or oozing, and should be bounded by freshly cut edges of healthy skin. The base must be free from scar tissue. The graft should be fitted accurately into its bed, and should be firmly fixed in place. It is usually wise to fasten the graft to the edges of the gap by means of a few very fine stitches. The use of sutures must depend greatly on the liability of the flap to become displaced. Sutures are usually necessary to hold a flap to the eyelid or to a portion of a finger; they may be dispensed with, however, in the case of larger flaps which are placed on a flat surface and are not liable to movement. It is important not to apply a ligature to any point which subsequently is to be covered by a graft.

The dressing of the grafts is important. Ventilated rubber protective tissue should be applied, as it prevents displacement of the skin through adhesion to the outer dressings and also prevents maceration by permitting the escape of fluids. Absolute immobilization of the part is essential, and the dressing should not be disturbed for at least two weeks without special reason. Where the gauze is placed directly against the skin, it is wise, if possible, to leave the original dressing undisturbed for even a longer period than three weeks. The graft should be kept firmly and evenly pressed against its bed.

Krause, in 1893, reported cases in which he had employed the same method, but in which he had transferred much larger grafts than did Wolfe; he advocated their use in a greater variety of cases. As Krause said in 1895, however, the method is to be used only when the Thiersch method is inapplicable.

The method is particularly useful in plastic work upon the fingers or hands, where the liability to cicatricial contraction is great, probably owing to the irritation of the exposed scar tissue caused by constantly repeated trifling trauma. Obviously, protection of the scar tissue by the entire thickness of the skin rather than by a thin layer of epithelium is a great gain.

There are certain disadvantages connected with the Wolfe-Krause grafting method. In the hands of most operators the likelihood of failure has been much greater than when the Thiersch grafts are employed. When the grafts are small and the surfaces clean, the chance of securing union is good. When ulceration is present, or the nutrition of the parts is impaired, the chance of success is poor. But, as with many special procedures, the personal surgical factor is very strong. The minute care and patience of some operators will lead to success in almost all cases.

The use, by Lusk, of the raised cuticle of a blister, and also of the same when dried and pulverized under antiseptic means and sown on the raw surface, should be mentioned as being more ingenious than practicable. Also thus may be mentioned the skin taken from the frog, the membrane inside the shell of an egg, etc.

Among grafts should be mentioned the complete and immediate transfer, for plastic purposes, of other tissues together with the skin. There are numerous recorded instances in which completely severed parts of the body have been successfully replaced. Fingers, toes, and noses have been thus restored, and such restoration should always be attempted where possible. In such attempts there is everything to gain and but little to lose. Of late, also, considerable experimental work has been done in the transfer of severed members, but so far the results have not been of practical value. Apparently, in the larger grafts of this sort success depends on the restoration of continuity of the arteries and veins.

Koenig, in 1902 (*Berliner klin. Wochenschrift*, XXXIX., 1, 37), excised and transplanted a small portion of the ear into the ala of the nose, holding the graft in place with stitches. Only a very small portion necrosed; the remainder lived and gave a satisfactory result. Cartilage, which formed a part of this graft, is free from blood-vessels, and yet it appears to have lived. Perhaps the freedom from blood-vessels renders this tissue less likely to necrose than vascular tissue. However this may be, the success of Koenig is so encouraging as to suggest the possibility of grafting other tissues along with skin. It has been found by histological study that grafts at first are nourished entirely by transudation, but that at the end of about four days there develop minute capillary vessels through which increased vigor and finally active growth are imparted.

The Reverdin grafts hasten the covering in of scar tissue by giving new points from which epithelium may spread; they also stimulate the vital activity of contiguous borders.

The Thiersch grafts cover in the area at once with epithelium, but the epithelium is still always closely adherent to the scar tissue and will contract if the underlying tissues contract.

The Wolfe graft, including the whole thickness of the skin, maintains its former characteristics. Hair continues to grow where it grew before. Sensation is restored promptly in the new position. The flap becomes movable on the underlying tissues, except at the edges where there is true scar tissue. There is also a layer of true scar tissue at the base of the flap, but this is usually so thin as not to cause any contraction or lack of mobility of the flap.*

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* Noesske: Deutsche Zeitschr. f. Chir., July, 1906, p. 213.

PROSTHESIS.

In many varieties of plastic work it is necessary that some inorganic material be introduced to fill a defect or to give support to parts which are defective. The material used may be removable or it may remain buried in the tissues.

False teeth and glass eyes and artificial limbs are of course prosthetic appliances. But the forms of removable apparatus which fill defects, and with which the surgeon interested in plastic work has to deal, are those designed for filling a cleft in the palate, for taking the place of a missing nose or ear, or for correcting a deformity in some other part of the body. Removable appliances intended to support a depressed nose are examples of another form of prosthetic apparatus; and the introduction, among the tissues, of a permanent support furnishes still another example of the utilization of prosthetic apparatus.

Gersuny, of Vienna, introduced in 1899 a new method of prosthesis. He injected vaseline, which melted at a temperature a little higher than that of the body. At about the same time Delanger tried the injection of spermaceti in plastic operations. Many others at once took up the method and applied it in innumerable ways. The correcting of the deformity known as "saddle nose" furnished, however, the widest field for the application of the method. Perhaps the value of the method, as well as its dangers and limitations, may be best stated by a brief review of the history of such injections. While vaseline was the first substance used, it soon became apparent that owing to its low melting-point, varying from 33° to 39° C. (91.4° to 102.2° F.), it did not become firm enough for many purposes. Slow absorption of the injected mass often took place. The mass also often became widely diffused, and in some cases emboli entered the circulation.

In order to secure a harder material, mixtures of vaseline and paraffin were tried, by Lermoyez among others. This mixture has a melting-point between 42° and 46° C. (107.6° and 114.8° F.). Eckstein, in 1901, substituted pure paraffin, with a melting-point of about 60° C. (140° F.), for mixed vaseline and paraffin. The danger of diffusion and slow absorption was diminished by the rapidity and firmness with which the mass hardened. The danger of embolism remained, though somewhat diminished; and this has been the great objection to all such substances. In many instances of injection into the nose there has been, as a result, embolism of the central artery of the retina, causing an immediate and irreparable blindness. A more terrible outcome from a cosmetic operation can scarcely be conceived possible. There have also been instances of pulmonary embolism. In still other cases thrombo-phlebitis has happened.

With the use of paraffin that had a relatively high melting-point (about 60° C.; 140° F.) a new danger arose. Burning of the skin and burning of the deeper tissues may occur at the time of the injection and lead to sloughing and deep suppuration. The special gravity of this coagulation necrosis and of suppuration about the injected material lies in the fact that recovery is impossible until the injected foreign body is entirely eliminated. The removal of the mass is most difficult owing to the manner in which it spreads through the tissues. Thus, not only is the original deformity not for long bettered, but the opportunity to adopt other methods of treatment is curtailed.

A clear knowledge of what happens when the material is injected gives one an understanding of the risks and the means of minimizing them. As the mass is squeezed from the syringe it follows the anatomical lines of least resistance. Therefore it is of the utmost importance that the area into which it is intended to force the injection should be most sharply and firmly limited by mechanical pressure. This pressure must be maintained until the mass has become hard; the lower the melting-point the longer the mechanical pressure is needed. The ideal tissues into which to force the injection are, of course, the loose subcutaneous fat with its intertwining bands of fibrous tissue. The injection spreads irregularly. There are fibrous bands running about and through the injection. The material acts as a foreign body, and, as in the case of any other foreign body, it tends to become encapsulated by fibrous tissue. Owing to the irregularity of the injected material it is plain that any fibrous bands running through the mass may also undergo hypertrophy. Thus, as the encapsulation goes on, it may be associated with a crumbling and breaking up only after a long lapse of time, and this is true even of those harder materials which have a high melting-point. Such slow breaking up of the mass has not proved uncommon.

Another untoward result is the overgrowth of fibrous tissue about the foreign body. There may be formed a keloid-like mass which is hard, red, and disfiguring. It is not improbable that an aseptic coagulation necrosis from too hot injection may add to the irritation sufficiently to favor this keloid-like formation.

In regard to the risks of phlebitis and embolism it should be stated that many of the reported cases have occurred where the injection has been made beneath mucous membrane. As Nélaton and Ombrédanne remark, however, it is a fact that in those cases in which injection under the skin of the nose results in the destruction of the cartilage or bone, or in which they have been previously destroyed, the injection is necessarily submucous as well as subcutaneous.

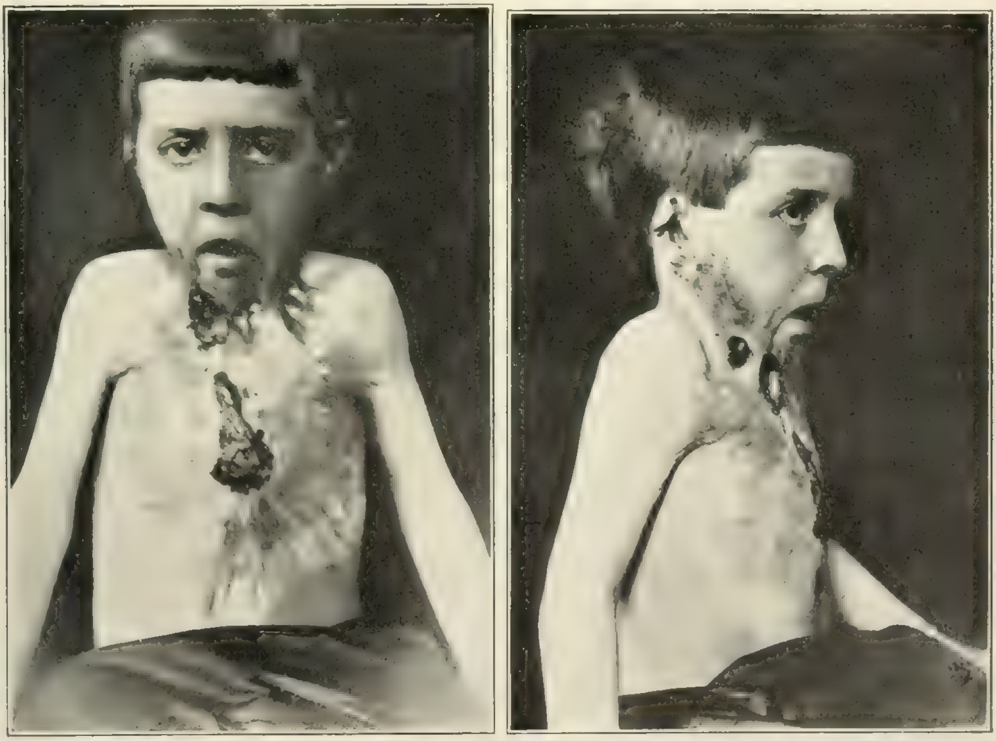
It is undoubtedly true that in many instances the results obtained have been immediately and permanently satisfactory, and yet with the increasing lapse of time the number of ultimate failures grows larger.

If the method is to be tried, the risks already stated should be clearly understood. It should further be remembered that the removal of the injected material, if it becomes necessary, is a most difficult procedure because of the interwoven meshes of fibrous tissue.

Certain definite rules should always be kept in mind. Such, for example, are the following:—1. Only very small injections should be made at any one sitting. It is wise always to wait for a number of days at least until all inflammatory reaction is passed before another injection is made. With these precautions the injections may be repeated as often as necessary. 2. Injections are never to be made near large blood-vessels or in particularly vascular regions, or under mucous membrane. 3. Compression about the area until the material has hardened, and absolute quiet in bed for some hours after the injection, are essential to minimize the risk of embolism. 4. Paraffin with a melting-point of about 52° C. (125.6° F.) is to be preferred, as it has been generally found the most satisfactory. 5. When the needle is removed, care should be taken lest any of the material be injected close to the skin at the moment when the instrument is being withdrawn.

PLASTIC SURGERY AS APPLIED TO DIFFERENT REGIONS OF THE BODY.

Neck, Trunk, and Extremities.—In correcting cicatricial deformities or in closing gaps left after operation in the skin of the extremities, trunk, or neck, no general rules can be laid down, unless it be that the skin most available



a *b*

Fig. 401.—Cicatricial Contraction Following Burn of Neck and Chest. (Original.) *a*, Front view; *b*, profile view.

should be used. In the extremities it is most important, if possible, to avoid scars on the flexor surface near a joint, owing to the risk of permanent contractions. It is well, in filling a gap left in a flexure, to swing a flap in in such a manner that its borders shall lie across, rather than parallel with, the length of the limb. In many instances Thiersch grafting is the best policy, even though it does not entirely prevent contraction.

In the upper extremity the transfer of abdominal or thoracic flaps is of the utmost value, especially if the avoidance of a scar is important. (Fig. 406.) In those terrible contractions of the neck which follow burns and scalds, the surgeon usually has to utilize whatever sound skin is left, whether it be on the chest, back, or arms. (Figs. 401 to 403.) Under no circumstances should the vitality of a flap be jeopardized by too great a desire to close the secondary gap. It is wise to correct any deformities of bones or muscles after the defects in the skin are corrected. (Fig. 404.)

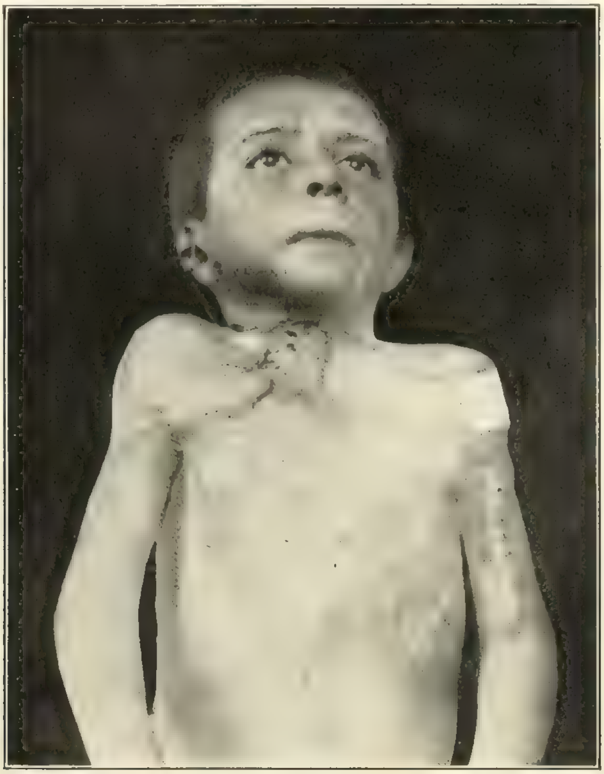


Fig. 402.—Cicatrix Extending from the Mouth to the Umbilicus. Condition of the parts after the transfer of flaps from the anterior surface of each arm to the front of the neck. (Original.)

The Scalp.—In closing a gap left through the loss of part of the scalp, Tillmanns has suggested turning into the defect three or four ribbons of skin taken from the sides. The operation is as if portions of the rim of a wheel were turned in and united at the hub to form spokes. Thus, a large gap is subdivided into several smaller ones. This gives additional edges from which new epidermis may spread out to cover in the exposed area. The pedicles of the flaps should be equidistant from each other. The free ends should be sutured together. (Fig. 405.) Among the operations described for the repair of the upper lip is that of Senn, who lowered a part of the scalp to close an enormous defect in the face exactly as the visor of a helmet is lowered. In an exactly similar manner portions of the scalp may be transferred to fill defects in other parts. The flaps may be left attached at each end and may be slid forward, backward, or sidewise. In this manner one larger may be divided into several smaller defects, thus giving additional borders from which new epithelium may spread out. An area of exposed bone may similarly be covered by a flap of skin which does not include the underlying periosteum. In this manner necrosis of bone may often be prevented. In the same way a primary defect may be closed by creating a secondary defect in a less conspicuous position. A primary defect also may be closed by creating a secondary defect in a place where it in time may be closed by turning in flaps from other parts in accordance with routine

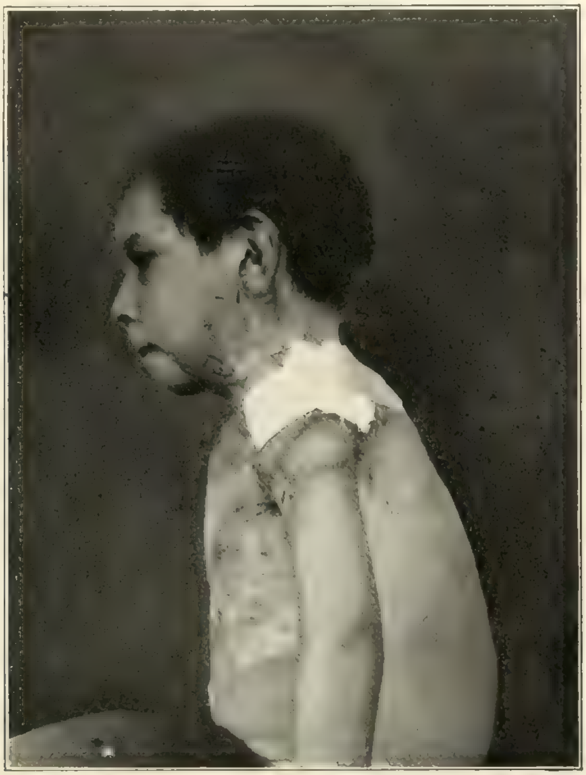


FIG. 403.—Lateral View of Same Patient as Preceding. Taken at Same Time.

methods. In extensive loss of substance of the scalp, repair has been effected by a patient and repeated application of Thiersch grafts.

The Hands. The various congenital malformations of the hand belong more properly to the realm of orthopedic than to that of plastic surgery. But there is no branch of plastic surgery which is more important than that which deals with preserving and restoring the usefulness of the hand after injury. The

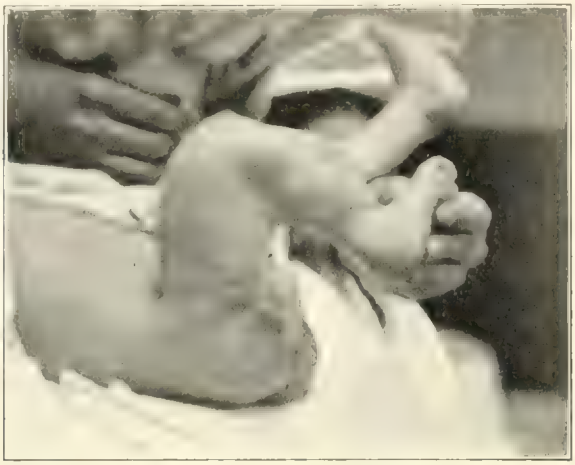


Fig. 404.—Cicatricial Contraction Extending from Heel to Buttock Causing Bowing of the Tibia and Femur as Well as Flexion of the Knee.

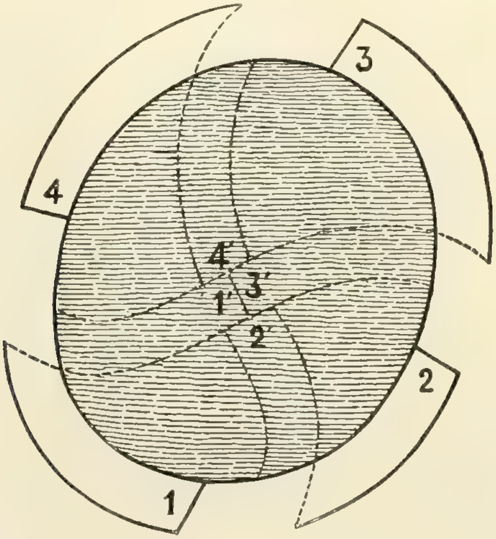


Fig. 405.—Tillmans' Method of Bridging Across a Defect in the Scalp. From around the borders of the defect in the scalp (shaded area) four flaps are cut. The free ends (1, 2, 3, and 4) all lie in one direction. The free end of each flap reaches nearly to the pedicle of the next flap. The dotted lines indicate the manner in which the flaps may be turned into the centre and united (1′, 2′, 3′, 4′). Thus in place of one large defect four smaller defects are created.

chief injuries with which the surgeon has to deal are those due to explosions, to crushing, or to burns and scalds. Oftentimes there is a combination of crushing and burning, as in the frequent accidents occurring in laundry mangles.

One must not be content with the correction of deformities after they are developed. It is of the utmost importance that every possible portion of the hands and fingers be preserved. The surgeon who amputates a finger because the skin is burned or crushed has not done his duty to his patient unless he has considered most carefully whether it might not be possible to preserve the part by covering it with skin from another region of the body.

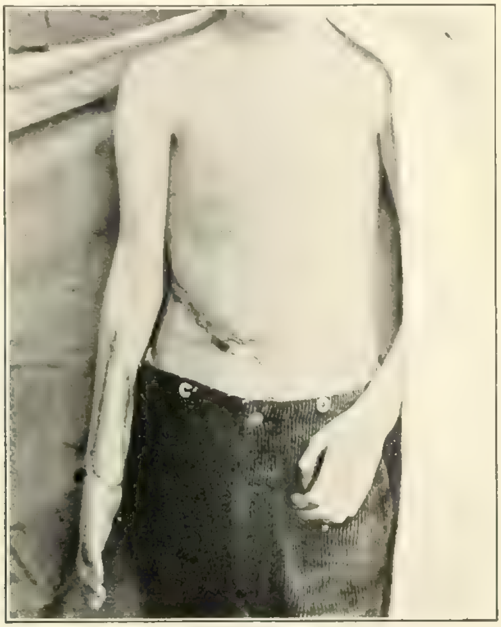


Fig. 406.—Abdominal Flap Transferred to the Forearm. Thumb Destroyed.

In plastic restoration of the hand the most valuable procedure, one far too seldom used, is an adaptation of the Italian method of fixing the part to the skin of another portion of the body, and then, after an interval, severing this flap. The method is not as easily applied to any other portion of the body as to the hand, forearm, and arm. It is a very easy matter, and a cause of comparatively slight discomfort, to fix the hand or fingers to a portion of the skin of the abdomen or chest. Certain general rules may be laid down with reference to the transfer of abdominal or thoracic flaps to the hand or arm. Thus, for example:

All deep scar tissue should be dissected away.

All resistance to complete unfolding of the hand should be overcome.

As far as possible, the edges of the skin which is left should be free from scar tissue.

Any preliminary work upon the hand may well be done under the control of a tourniquet.

The incisions to free the flap and to fit it to the denuded surface must be accurately patterned, with allowance of about a fourth for shrinkage. This may easily be done by placing the supinated hand if the defect is in the palm, or pronated if it is on the back, just below the area from which the flap is to be raised.

The flap should include about 1 cm. ($\frac{2}{5}$ in.) of subcutaneous fat. More than this is objectionable in appearance and is not needed for maintaining the nutrition unless the area freed is exceptionally large in extent.

Suppuration is practically inevitable on account of the impossibility of properly dressing portions of the denuded area.

On account of the probable suppuration, no plastic work on bones, joints, or tendons should be undertaken at the time of the operation on the skin.

The free borders of the flaps should be stitched to the skin, at the borders of the area to be filled, with the greatest possible accuracy, in order to secure primary union and to minimize scar-tissue formation.

The pedicle, still attached to its base, may be approximated by quilted sutures to the opposite edge of the gap on the chest or abdomen. These quilted sutures must not be so tight as to interfere with the circulation of the flap. They should be introduced exactly along the line at which the attached border is to be severed later. Under no circumstances should these sut-

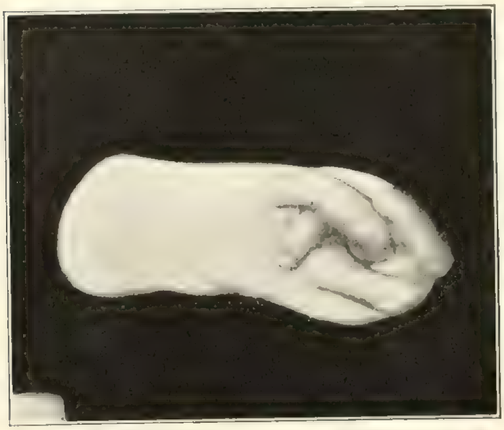


FIG. 407.—Contracted and Immovable Hand after Cicatricial Contraction Due to Burns in a Mangle.

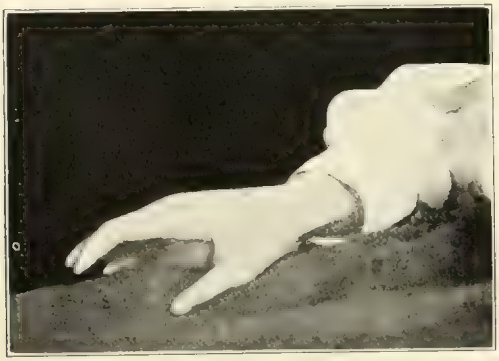


FIG. 408.—Same Hand with Fingers Extended after Transfer of Abdominal Flap.

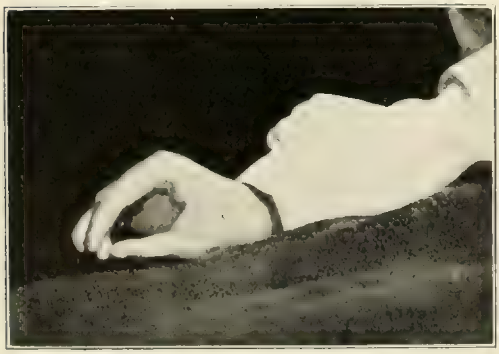


FIG. 409.—Same Hand with Fingers Flexed.

ures come within the area to be cut free later. If they are not originally placed with care, it is difficult to judge at the second operation along just what line the flap is to be freed.

As far as possible the corners of the thoracic or abdominal wound should be approximated at the first operation, in order to minimize the area left uncovered.

At the second operation the condition of the wound is usually such that accurate suturing of the flaps, either on the abdomen or on the hand, is inadvisable.

The area from which to cut the flap should be selected chiefly with reference to an easy position of the arm when fixed to the side during repair.

The flap may be attached above, below, or at the side, or it may form a bridge, being left attached at both ends.

The flap should, if possible, not cross the median line of the body. Nor should dependence be placed on the nutrition of the flap if the only vessels left intact cross the median line.

An interval of from fourteen to twenty days should elapse between the two operations.

The earlier after the original injury the plastic operation is performed the better is the functional result to be expected. It is often unnecessary to wait for cicatrization after the original injury. The operation may be performed as soon as the line of demarcation of the gangrenous tissue appears, or, in non-gangrenous cases, as soon as the primary inflammation has subsided.

The entire extremity should be fixed to the body by a plaster-of-Paris bandage. This should not be removed until the patient is fully anaesthetized for the second operation, and then the utmost care is necessary lest the flap be torn free.

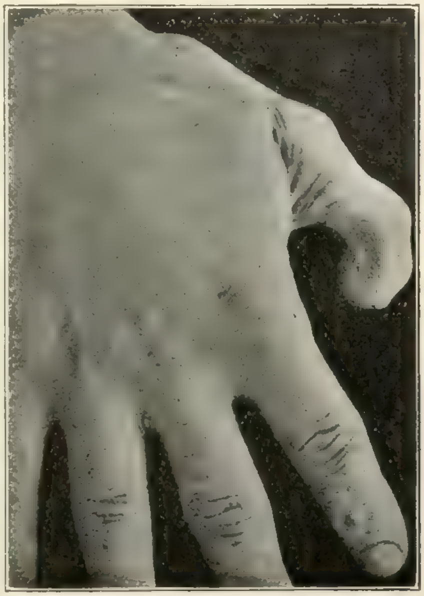


Fig. 410.—Substitution of Second Toe for Lost Thumb. (After Nicoladoni.)

Restoring a Lost Thumb.—Nicoladoni* has devised a most ingenious operation for replacing a lost thumb. (Fig. 410.) He substitutes the second toe of the same side for the missing thumb. The transfer is done in two operations. At the first he makes a wide flap on the dorsum of the foot and unites the first phalanx of the toe to what remains of the first phalanx or metacarpal of the thumb with a silver-wire suture. The flap from the dorsum of the foot is sutured accurately to the outer aspect of the skin at the base of the thumb. In Nicoladoni's cases bony union had occurred in about sixteen or eighteen days. At that time the flap at the plantar surface was severed and sewed into the angle of the thumb. In his two cases the nutrition became sufficiently established to prevent sloughing after the toe was completely severed from the foot. In neither of them was he able to secure good motion in the thumb. In one case he sutured the tendon on the dorsal surface at the first operation, and in the other he waited until the second operation before suturing the tendons. In neither case was free use of the tendon secured. The tendons were bound up in the scar in each case. Although this lack of mobility was a drawback, yet the thumb remained fairly useful because of the motion transmitted to it through the muscles which are attached to its metacarpal bone. If, owing to cicatricial adhesions, the motion secured is so slight as to be of little use, Nicoladoni suggests that it might be easily possible to free the tendon and cover in the wound, left after the excision of the scar tissue, with a flap from the chest. When the operation is done in childhood the nutrition of the new thumb is not sufficient to insure full growth. Apparently the disturbance is chiefly in the epiphyseal line. The length of the thumb is deficient, but it grows in breadth and thickness. This method of supplying the thumb is to be preferred to that of transferring pieces of the tibia and then covering them with a flap of skin from another part.

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* Archiv f. klin. Chir., Bd. lxix., Hft. 3.

In cases in which the tendons are more or less destroyed, the possibility of tendon lengthening by Lange's method (Vol. II., p. 415) is to be considered.

Webbed Fingers. Syndactylism.—The degree of the deformity varies very greatly. When the fingers are united by a web only a third as thick as the diameter of the fingers, and broad enough to allow the fingers to be spread apart for a third of their diameter, the skin can be united without tension after division of the web. The difficulty of bringing the edges of the skin together increases as the web is thicker and narrower. Unfortunately, in most instances the union of the fingers is much too close and the web much too thick to permit ready suture of the skin after the division of the web. In fact, in many instances the union of the fingers is so intimate that the nails are fused, while in extreme instances the phalanges are also fused.

It must be recognized at once that, except in the most favorable cases, it is unwise to attempt to separate more than one web at a single operation. The amount of available skin, always scanty, is often insufficient to cover the denuded areas. Time allows the skin covering the other fingers to stretch and makes the conditions for later operations more favorable.

Primary union is always to be desired because it insures against cicatricial contraction of the scar and subsequent deformity of the fingers. In case primary union does not take place in the angle between the fingers, or unless a separation at this point has been previously established, it is inevitable that, as healing goes on, the divided web will to a certain extent reform. Even if precautions are taken, it is surprising to observe how frequently a web, apparently sufficiently separated, will tend to spread down between the fingers. For this reason it is well to establish the new commissure between the fingers at a point somewhat higher than is normal.

Several methods have been devised for establishing this point of separation before resorting to the division of the remainder of the web. One procedure has for its object the formation of a permanent cicatrized fistula between the fingers at the point where they should separate. The risks of sepsis, as well as the prolongation and discomfort of treatment without compensating advantages, condemn the method. The desired result may be secured more advantageously by stitching a triangular flap from the dorsum of the web to the skin of the palm where the normal point of separation is to be established. Neither of these procedures is to be advised. Primary union of well-formed flaps is the only method by which deformity of the fingers through contraction of the scar can be avoided.

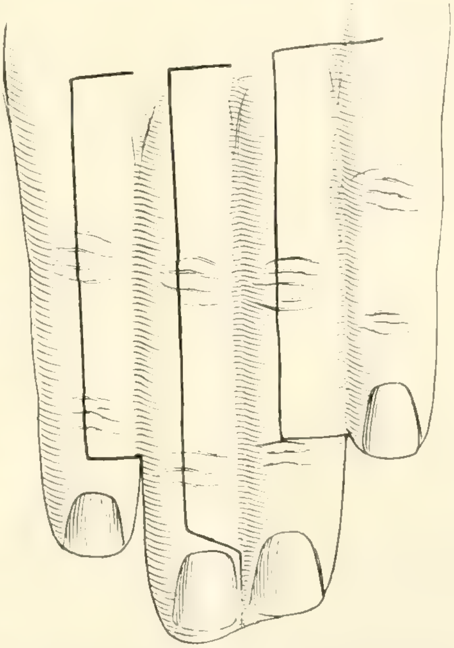

Fig. 411.—Diday's Operation. Diagram illustrating the incisions on the dorsal surface. The incisions on the palmar surface should be exactly reversed.

To meet these conditions, the operation variously spoken of as Nélaton's or Didot's—but in reality first described by Diday—is to be chosen. (Figs. 411 and 412.) In this operation a flap is to be raised from the dorsal surface of one and from the palmar surface of the other finger of the two to be separated. The flaps are to extend from the apex of the web backward fully as far as the location of the normal web. After the flaps are raised, the underlying tissues uniting the fingers are to be divided. In doing this, the surgeon should begin the cut at the tip of the fingers and should carry it toward the hand. With care to keep exactly in the middle line between the fingers there is little danger of cutting the vessels which are important in maintaining the circulation and in preventing sloughing of the flaps, which often have to be subjected to considerable tension. The

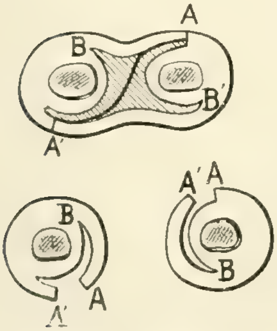

Fig. 412.—Diagram Showing in Cross-section the Manner in which the Fingers are Separated in Diday's Operation. The shaded area represents the subcutaneous fat which must be removed to allow union of the skin around the separated fingers.

flap from each finger is thus left attached to the adjacent finger and is to be sutured carefully into place.

Even in cases in which, before division, there seemed abundant skin, it is common to find the flaps subjected to considerable and possibly dangerous tension. Under these conditions one must cautiously dissect away the superfluous fat from the exposed sides of the fingers, care being taken to avoid cutting away enough tissue to interfere with the vitality of the flaps. The vessels and nerves ought to be spared.

Diday's operation is always to be selected except in the rare cases in which the web is so thin and so broad as to allow suture of the surfaces after direct division without flap formation. One must remember, however, that Diday's operation does not add one jot to the amount of available skin. If the skin is deficient it merely transfers the line of the scar from the sides of the finger to the dorsal or palmar surface.

If, at the first operation, one finger is separated from two or more, it is wise to fashion the flaps in such a manner that the one left for the separated finger shall be broader than that left on the several united fingers. The opportunity for stretching the skin is greater the more fingers it covers.

When the fingers are placed so close together as not to permit their separation with sufficient tissue to cover in the raw surfaces, one should carefully consider the advisability of securing additional skin by means of abdominal flaps. It is of such prime importance to secure useful fingers that any reasonable measures should be taken to prevent their being stiffened or deformed or their nutrition and growth impaired in any way by scar tissue. The use of an abdominal flap is certainly far preferable to the excision of the bones of one finger in order to secure sufficient skin to cover the others, unless of course these are supernumerary fingers. The method of attaching the abdominal flap would be similar to that described for restoration of the skin of the hand. (Fig. 413.)

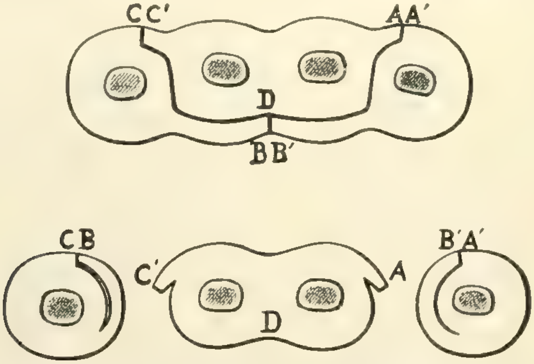

FIG. 413.—Diagram Illustrating a Way in which the Skin May be Utilized to Cover Two Fingers Completely, this procedure leaving on two fingers that are still united a large area, *A D C′*, which will have to be covered with a flap from the abdomen. Enough skin must be supplied to fill the extra denuded area left when the two fingers are separated.

The Face.—As a very large proportion of all plastic operations are done upon the face, it is fortunate that in this locality there are many favoring conditions. The free blood supply of the face favors prompt healing and tends to prevent septic infection of the wounds. Another advantage lies in the ease with which flaps may be transferred without fear of sloughing. Yet, in spite of the vascularity of the face, ligation of vessels is seldom necessary. This is advantageous in that it avoids the introduction of a foreign body within the wound.

In planning flaps, it is important, where possible, to have incisions and consequently scars follow the natural folds in the skin. Thus, scars in the nasolabial fold, in the angle between the nose and cheek, and in the fold that reaches down from the ala outside the mouth, are relatively inconspicuous. Scars on the forehead, unless concealed by the hair or eyebrows, are most conspicuous. Marked deformity must inevitably follow any operation which involves cutting any fibres of the facial nerve. Therefore, in making incisions on the cheek the course of these fibres, as well as the course of Steno's duct, must be kept constantly in mind.

The skin of the forehead, the temples, and the eyelids is thin, lax, and freely movable. It is thus, indeed, very well suited for plastic operations. That of the cheek, being thicker and more adherent to the underlying tissues, is therefore less suitable, while the skin from the neck contracts so much as to lose a large part of its value. Scar tissue involving the whole thickness of the skin in a flap greatly endangers its vitality. While the flap is being dissected it is very important that the tissues should not be pulled out of shape. Where possible, the pedicle should be left at a point where it is likely to contain large blood-vessels. It may then be narrower, and the narrower the pedicle the more easily it is swung into position and the less the deformity produced by change in position. Gersuny first utilized flaps with a pedicle of subcutaneous tissue alone. This has proved to be a most important step in closing defects in the mucous membrane. By this means a flap may be folded into position through a slit cut in the skin. Monks has used flaps nourished only by important blood-vessels dissected free from the surrounding parts.

As a general rule, curved incisions are always to be preferred to straight incisions. Thus, it is always of great assistance in turning a pedicle to prolong the incision on the convex side in a slight curve.

Great accuracy of apposition in suturing is always important. The more accurate the apposition the less the stretching of the scar. Pliable sutures are to be preferred to stiff sutures, and sutures which have no capillary meshwork are to be preferred to those which have.

It is important, in order to prevent spreading of the scar, that the layers of fascia under the skin be firmly united. This cannot well be done with a subcutaneous stitch, which therefore should be used only in those cases in which there is no tension on the flaps. A subcutaneous stitch should never be used in those cases in which infection may occur. Thus, for example, it should not be used in operations in which the mouth has been involved. As far as possible all gaps which are formed by the removal of flaps should be united by a suture at the time of the operation, or, if this cannot be done, should be closed by Thiersch grafts at the time. Unless it is absolutely unavoidable, no areas should be left to heal by granulation. It is extremely important that under no circumstances should the pedicle of a flap be put under the slightest tension or compression. This may happen unless care be used in suturing the gap left by the removal of the flap.

The mucous membrane, as well as the skin, often requires a suture. Fortunately, in many cases in which mucous membrane has been destroyed, flaps of skin may be substituted, but no hairy surface of skin should ever be turned into the mouth.

It is important above all else to maintain the general contour and symmetry of the two sides of the face. The utmost care should be taken to prevent tension of the flaps from pulling the eyelids or lips out of place. As far as is consistent with other requirements the minimum of tissues should be destroyed, and incisions should be as short and simple as possible. In certain branches of plastic work temporary osteoplastic resections and temporary plastic resections of the nose are of the utmost value.

Sensory nerve conduction is re-established very promptly in plastic operations. There is always a tendency for any projections of skin left after a plastic operation to flatten out. This is a most important aid to the surgeon in the spontaneous correction of any irregularity which may be left after plastic operations, but, on the other hand, it is fatal to the success of many operations which are intended to create any prominence such as is aimed at in rhinoplastic operations and in operations intended to build up defects in the ear.

While no definite line can be drawn as to the extent to which minor cosmetic operations should be undertaken, and although the risk is trifling, yet one must remember that there are risks in any operation. It is especially important that the immediate dangers and the remote unsatisfactory after-effects of paraffin injections should always be kept in mind. The frequent urging on the part of patients to have some cosmetic operation performed, should never be allowed to override the conscience of the surgeon. It is also wise not to encourage expectations, on the part of the patient or friends, that are inconsistent with the influence of the obstacles to be overcome. It should not be forgotten that complaisant co-operation, on the part of the surgeon, with the irrational anticipations or morbid imaginings of a patient are apt to be disappointing to all concerned, providing for common observation an exhibit which is likely for a long time to annoy the patient and torment the surgeon.

Meloplasty.—Meloplasty, or reparative surgery of the cheek, is necessary after the removal of new growths, after destruction by accident or disease, for the closure of congenital defects, and to remedy cicatricial lockjaw.

In plastic operations upon the cheek, the surgeon meets the difficulty of providing an inner mucous as well as an outer cutaneous surface. In many cases, also, as a result of cicatricial contraction, there is an ankylosis of the jaw of greater or less extent. The choice of the method of operation, therefore, must depend greatly on the extent of the destruction of the external and internal surfaces, and on the mobility of the jaw.

Defects which involve the skin and subcutaneous tissues may, if small, be closed by undermining the edges and suturing them together. Larger superficial defects are best closed by means of skin grafts. Sometimes, however, flaps had better be turned in from some neighboring part. Where a flap is turned in, it had better come from behind the gap, but, in cases in which the skin is insufficient, the flaps may be taken from the lower jaw or from the neck. In determining the position from which the flap shall be taken, much must depend upon the condition of the skin about the lips and eyelids. Above all else it is essential that the eyelids shall not be drawn upon in such a way as to cause ectropion, and, if it is possible, the mouth should be left undisturbed, or, if disturbed, should be restored later to its normal condition. Any deformity of the mouth is always most conspicuous.

In those instances in which the loss of substance is in the mucous membrane alone and is not too extensive, and in which the mucous membrane elsewhere is sound, it is best, when such a course is practicable, to take the flaps needed for repairing the defect from either the upper or the lower lip.

The mucous membrane from the hard palate may be utilized to fill in gaps of moderate extent in the mucous membrane of the cheek. A flap can be made with a pedicle that is placed posteriorly and that therefore may be swung outward into the cheek through the gap behind the teeth. A procedure of this sort may be useful in those very rare cases in which ankylosis of the jaw has resulted from cicatrices situated far back in the cheek. The risk of sloughing in such a flap is considerable.

Willard Bartlett* has recently reported an ingenious use of the tongue for filling a gap in the inner surface of the cheek in a patient in whom the teeth, on the side involved, had been previously lost. The tongue was split longitudinally along its lateral border. The upper half was sutured to the upper border of the defect in the mucous membrane of the cheek, and the lower portion to the lower border. The operation, of course, requires the removal of any teeth that may be on the side of the operation, but it is not essential that the teeth should have been previously lost. The mobility of the tongue is so great that the fixation of one side to the inner surface of the cheek does not impair its usefulness.

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* Annals of Surgery, xlv., p. 573.

Fortunately, in defects of the cheek, when sufficient mucous membrane is lacking, flaps of skin may be turned in and utilized. Although in time the character of the skin will change materially and will come to resemble mucous membrane in many respects, one must remember that hair continues to grow on the inturned surface. Therefore, no part of the bearded face should ever be thus used, unless measures have previously been taken to destroy the hair.

Various methods have been proposed by which deficiencies in the mucous membrane may be filled by flaps of skin passed through a slit cut into the mouth as well as under flaps which have been temporarily reflected. Rotter has proposed introducing a flap through a slit at the anterior edge of the masseter. Bardenhauer has proposed introducing a flap of skin from the forehead or arm through a slit extending from the ala nasi to the malar bone. Roberts ("Deformities of the Face," p. 34) has suggested inverting a flap of skin from the neck through a slit into the mouth at the margin of the lower jaw. The procedure of Shrady has already been described (see page 618).

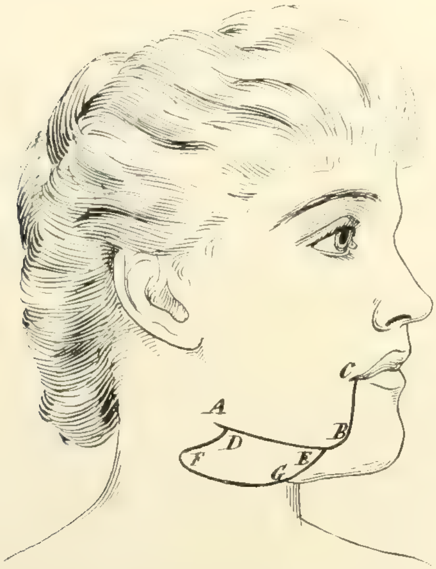


FIG. 414.—Gersuny's Operation. The flap *A B C* is reflected from the jaw. The second flap, *D E F G* is then cut of proper size to fill any gap that may exist in the mucous membrane of the cheek. This flap is to be folded up, the subcutaneous tissue along the line *DE* being the pedicle. The flap *A B C* is then to be replaced.

THE OPERATION OF GERSUNY.—This operation is one in which deficient mucous membrane is supplied by skin folded up from the neck. It is peculiar in that the pedicle consists of subcutaneous tissue only. While this fact enables the surgeon to complete the operation at one sitting, the nutrition of the flap is so precarious as to make the operation unreliable. An incision is carried downward from the corner of the mouth to the border of the lower jaw, and then extended backward to the edge of the masseter. The flap thus formed is separated from the jaw and held upward. Any cicatricial tissue in the mucous membrane may be divided, or a tumor removed. The resulting gap is to be filled by turning a second flap of appropriate size upward from the neck. The pedicle of this flap includes the subcutaneous tissues and periosteum along the margin of the jaw. In order that the flap may be raised up into place, it is usually necessary to cut the periosteum along the margin of the jaw and free it somewhat. The flap is then sutured to the edges of the gap in the mucous membrane. The first flap is turned down again and sutured in its original position. (Fig. 414.)

The cutting of the second flap gives admirable access to the submaxillary lymph nodes. The gap in the neck may be closed by direct suture, by appropriate flaps, or by Thiersch grafts.

Obviously in men the operation is undesirable because a bearded portion of the neck would be turned into the mouth.

Numerous similar methods have been suggested. Eiselberg has taken skin from a beardless portion of the cheek. The hairless portion of the neck may also be used, and thus a scar on the face may be avoided.

In those cases in which the whole thickness of the cheek has been destroyed, ankylosis of the jaws is usual, but there are a few instances in which the mobility is not impaired.

In repairing many of the minor defects involving the entire thickness of the cheek, direct union of the refreshed edges of the gap is possible. This is true especially of the rare congenital fissures of the face, and it may also be true of certain minor destructive changes.

When direct union is impossible, flaps must be used. When the loss is not too great, pedunculated flaps may be formed from the upper part of the cheek and from the side of the lower jaw, and these can be slid together and approximated. This method of gliding flaps is best when it can be used. It has the great advantage of using flaps which have already a mucous as well as a cutaneous surface. (See Fig. 415.)

However the defect may be closed, it is of great importance that the mucous and cutaneous surfaces should be thoroughly separated down to sound tissue. If this is not done, union is less perfect, and the scar is likely to be depressed.

If for any reason pedunculated flaps cannot be taken, the gap may be filled by reflecting a flap of skin from over the masseter, with its base near the defect. Or a flap may be turned up from immediately below the defect, as in Kraske's method. As much subcutaneous fat as is possible should be taken with the flap, but care is required if injury to the facial nerve is to be avoided. The skin must be sutured very carefully to the refreshed mucous membrane at the sides of the cavity. In cutting the flap, the pedicle may be left a short distance away from the border of the gap to be filled. If this is done, a reflected portion of skin is in-

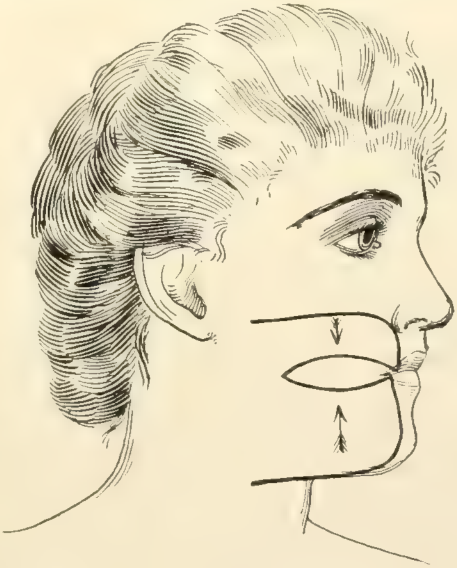


Fig. 415.—Union by Flaps from Upper Part of Cheek and Lower Jaw.

cluded in the pedicle, and to this extent the nutrition of the flap is assured. Kraske, however, has carried the incisions which free the edges close up to the defect, and has undermined the flap to within about a centimeter ($\frac{2}{5}$ in.) of the edge of the defect. In this manner the nutrition of the flap is maintained through the subcutaneous tissue only. The conditions in each case must govern the surgeon in determining what his procedure shall be. In cases in which there is much scar tissue about the edges of the gap, the method of Kraske involves considerable risk of loss of the entire flap. If there is doubt, it is much wiser to leave a little bridge of skin. This is cut across at the end of about three weeks, and there are thus left to be filled two areas, each the size of the flap, separated by a narrow strip of skin.

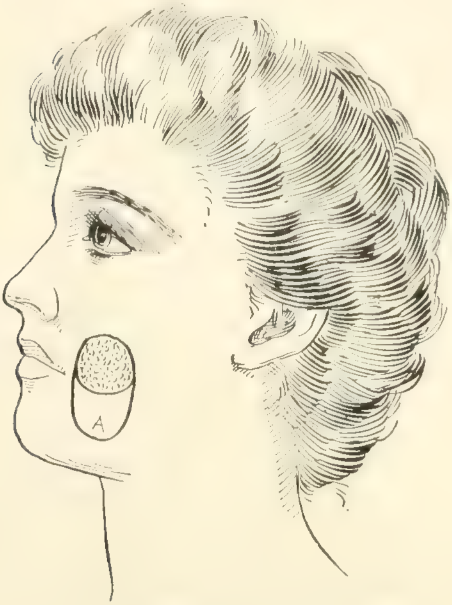


Fig. 416.—Kraske's Operation. The flap *A* is folded up into the defect.

In either case there are left raw external surfaces that are twice the size of the flap; and these may be grafted or filled by secondary flaps at once or later, according to the necessities of the case. The raw surface may often be closed satisfactorily by making a curved incision downward and backward under the jaw from the anterior edge of the original flap after it has been turned into position. Thus the skin may be undermined and slid upward into position to cover the raw surface. (Fig. 416.)

Gussenbauer's Operation.—In cases with a relatively small defect in the cheek, but with ankylosis of the jaw, the operation of Gussenbauer is useful. This operation is done in stages. At the first operation a trapezoidal flap of skin about 4 cm. ($1\frac{3}{5}$ in.) broad anteriorly and 6 cm. ($2\frac{2}{5}$ in.) posteriorly is cut out on the cheek. The flap is dissected from the corner of the mouth backward to the masseter muscle. It is left attached there by the broad pedicle. (Fig. 417.) The deeper cicatricial surface of the cheek is then divided by a single incision directly backward from the corner of the mouth to the masseter muscle. Then the mouth may be opened. The flap of skin is then folded in so that its anterior border may be sutured to the mucous membrane at the edge of the masseter at the end of the horizontal incision.

At the second operation, performed after the lapse of four weeks, the pedicle of the flap is cut across and the external surface is folded inward to line the cheek at the corner of the mouth. The cicatricial bands, which were cut across to permit the opening of the jaw, may be reflected to form new gums for the upper and lower jaws.

At a third operation the raw external surface of the first flap may be covered in by turning up a flap from the border of the lower jaw.

A large defect in the cheek, with little sound skin and with complete closure of the jaws, makes a condition most difficult to remedy. The cicatrix which fixes the jaw must first be divided so that the mouth can be freely opened.

In restoring the cheek it is essential to provide against such shrinkage of the flaps as may lead to fresh ankylosis of the jaw. This requires that neither the inner nor the outer surface of the restored cheek be left exposed to heal by granulation. In small defects it may be sufficient to have the inner surface of the flap covered by Thiersch grafts before it is fixed in place. But for large areas, this method of lining the inner surface of the flap may not prevent undue contraction. On the other hand, the external surface of a flap which has been so folded that the skin is toward the mouth may be covered with grafts with much less risk of troublesome contractions.

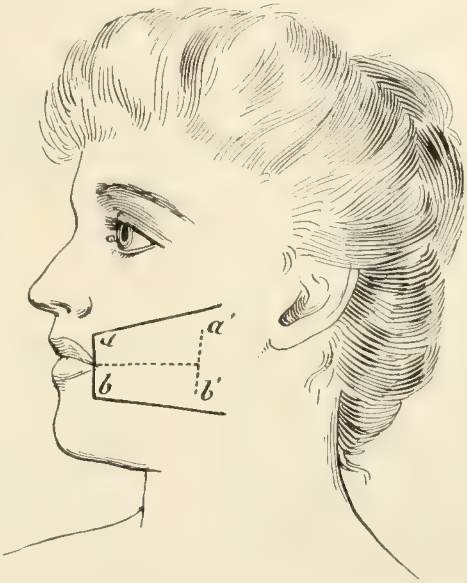


Fig. 417.—Operation of Gussenbauer. First stage: The solid line represents the incisions in the skin. The dotted line that in the cicatricial mucous membrane; the end of the flap of skin is folded in and sutured to the mucous membrane when the mouth is opened, *a* to *a′* and *b* to *b′*.

Many flap operations have been devised for filling these extensive losses in the cheek. The choice must be governed by the conditions which happen to be present. Flaps taken from the neck shrink more than those taken from the face. Although many operations are mentioned, the advisability of the Italian method of bringing skin from the arms should always be considered most carefully.

Czerny's Operation.—A flap is taken from behind the defect in the cheek. The pedicle is between the ear and the zygoma; the tip of the flap extends far downward and backward over the sterno-mastoid. (Fig. 418.) The flap should be relatively thick. Care should be taken, however, not to wound the branches of the facial nerve just below the pedicle. The flap should be long enough to allow the rounded tip to be folded back on to the main body of the flap and sutured to the mucous membrane at the edges of the defect. If planned carefully, this tip, which is to be turned into the mouth, may be taken from the hairless portion of the neck behind the lower part of the sterno-mastoid.

Obviously, a secondary operation is necessary to restore the corner of the mouth and, if necessary, to excise any redundant tissue where the flap was turned upon itself.

Israel's Operation.—This operation requires at least three sittings. At the first a long vertical flap of skin is dissected up from the side of the neck. (Fig. 419, *a*.) The pedicle is located just behind the angle of the jaw, is oblique in direction, and is somewhat farther from the edge of the gap to be filled than that point is from the proper location of the corner of the mouth. The width of the flap should be sufficient to fill the gap without tension; the length should be sufficient to enable the tip of the flap to reach the point at which the new corner of the mouth is to be formed. This will require that it should extend down to a point near the clavicle, as the skin of the neck contracts greatly. The flap should include the skin and subcutaneous tissues. In planning this flap in the case of men, it is important as far as possible to get the tissues from that part of the neck which is situated behind the beard. When thoroughly freed, the flap is folded forward so that the skin shall be inside. The lower portion of the flap, which, when folded on its pedicle, becomes the anterior portion, is then sutured to the refreshed mucous membrane at the edges of the defect to be filled. (Fig. 419, *b*.) The posterior part of the flap lies with its skin surface toward the

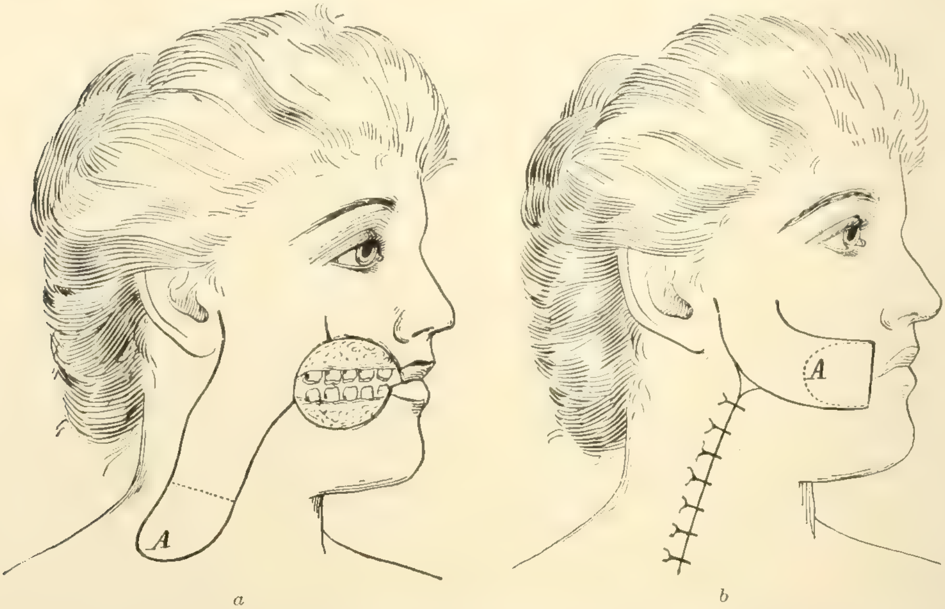


Fig. 418.—Czerny's Operation. *a* Represents the formation of the flap; the dotted line indicates the point at which the skin is to be reflected to fill the defect in the mucous membrane of the cheek. *b* Indicates the flap in position and the freshly denuded area united by suture; the tip *A* is shown folded back into position.

portion of the cheek which is situated just behind the defect, and thus the entire raw surface of the flap is left exposed. The area from which the flap has been dissected is then sutured by stitches placed transversely. The lower portion of the denuded area can be closed completely, but at the upper portion care should be taken not to place the stitches so close to the pedicle as to impair the circulation in the flap or to drag on the lower part of the cheek in such a manner as to draw it away from the portion of the flap that is sutured into the gap.

Great care should be taken to get accurate apposition between the edges of the mucous membrane and the flap at the upper and lower borders of the defect.

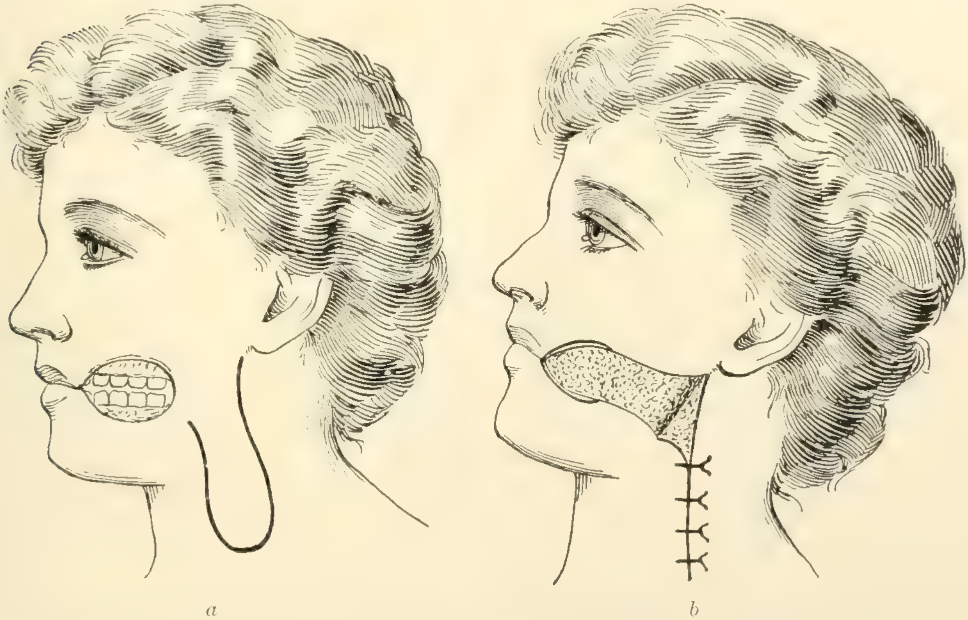


Fig. 419.—Israel's Operation. First stage. *a*, The flap is outlined. *b*, Flap in position. The secondary gap is closed by sutures.

At the posterior border, unless under exceptional conditions, no attempt should be made either to refresh the edge of the mucous membrane or to unite it to the flap. Under ordinary circumstances, any attempt made at the first operation to introduce sutures at this point would threaten the life of the anterior portion of the flap. The two surfaces of skin which are opposed to each other are to be kept apart by gauze to prevent maceration. As far as possible, leakage of saliva through the posterior portion of the defect is to be prevented. The sutured area in the neck may often with advantage be sealed, in order to prevent contamination from saliva or from the discharges from the exposed raw surfaces of the flap. It is well to dress the exposed surface with some smooth material which will not adhere.

The second operation is to be performed about three weeks later. The pedicle is to be cut across at its base. After this is done, the outer granulating surface of the whole flap is curetted and cleaned. The posterior part of the flap, now free, is turned forward and united at the corner of the mouth to the anterior free border. Above and below, the edges of the flap are carefully united to the refreshed edges of skin at the borders of the original gap. (Fig. 420.)

There remains still a sinus leading into the mouth just behind the flap. No attempt should be made to close this until the outer layer of the flap has united firmly to the inner layer. Otherwise there is great risk of cutting off the nourishment from the outer layer of skin.

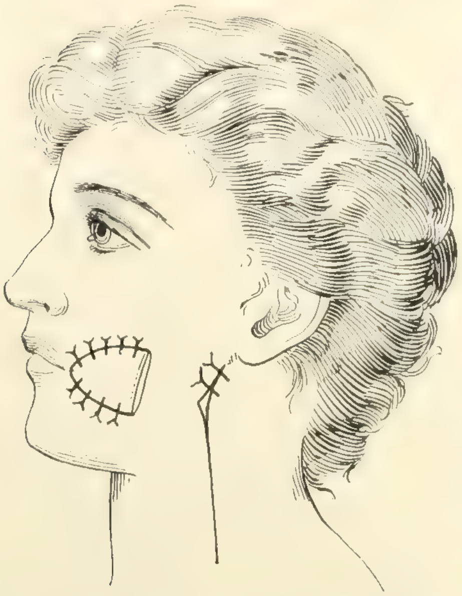


Fig. 420.—Israel's Operation. Second stage. Flap severed from the pedicle and folded forward upon itself to form the external layer. The gap at the posterior part of the defect remains to be closed at a third operation.

This opening or sinus is to be closed at the third operation by cutting perpendicularly through the flap where it was reflected, and suturing the inner layer of skin to the mucous membrane, and the outer to the skin just back of the opening. It is important to separate freely the edges of the inner and outer layers of the flap and also to separate freely the mucous membrane from the skin behind the opening. Scar tissue should be freely excised.

The mucous membrane of the upper and lower lips also should be dissected free and sutured in such a way as to meet at the corner of the mouth. This may be done at the second operation unless it is probable that changes in tension made at the third operation may again draw the corner of the mouth out of shape. The restoration of the corner of the mouth had usually best be left until the last.

When the pedicle is cut across, the surgeon should estimate carefully the length of flap required, and, in case the original flap seems likely to be too short to reach forward to the mouth, a little additional skin should be dissected up from the cheek just above and in front of the pedicle and turned forward as a portion of the flap.

The Operation of Hahn.—This operation is essentially the same as that of Israel. The flap is taken from the chest instead of from the neck. A large flap is cut out with its base at the clavicle and reaching down on to the chest as far as the nipple. The flap is folded up in such a manner that the skin faces inward and is sutured to the edges of the mucous membrane. The head should of course be held flexed and immobilized.

At a second operation the pedicle is severed and turned up to form the new cutaneous surface. In all essential particulars the technique is the same as that employed in Israel's operation.

THE OPERATION OF BARDENHAUER AND SCHIMMELBUSCH.—This operation is so mutilating that it is to be considered as a possible resort only under the most extraordinary circumstances. Two flaps are taken, at least one of which should be free from hair in order to fill the gap in the mucous membrane. One is taken from the forehead, with the pedicle either above the zygoma or at the root of the nose; the other is taken from the side of the neck, with the pedicle at the margin of the lower jaw. One flap is twisted or folded in to supply the defect in the mucous membrane; the other is at once sutured over it to the borders of the skin about the defect.

At a later time the pedicles of the flaps may be divided; if necessary, the corners of the mouth may be reconstructed and the secondary defects created by the operation closed, unless these defects have been remedied by Thiersch grafting at the time of the original operation.

Monod and Van Verts operate in a similar manner. They locate the pedicle of the flap from the forehead at the root of the nose. They cut it very narrow, taking care to include the facial artery.

In these operations the surgeon should remember that the long pedicles, after being severed, are returned to their original positions. Therefore the portions of the secondary defects created which are near the pedicle need not be closed either by suture or by grafting.

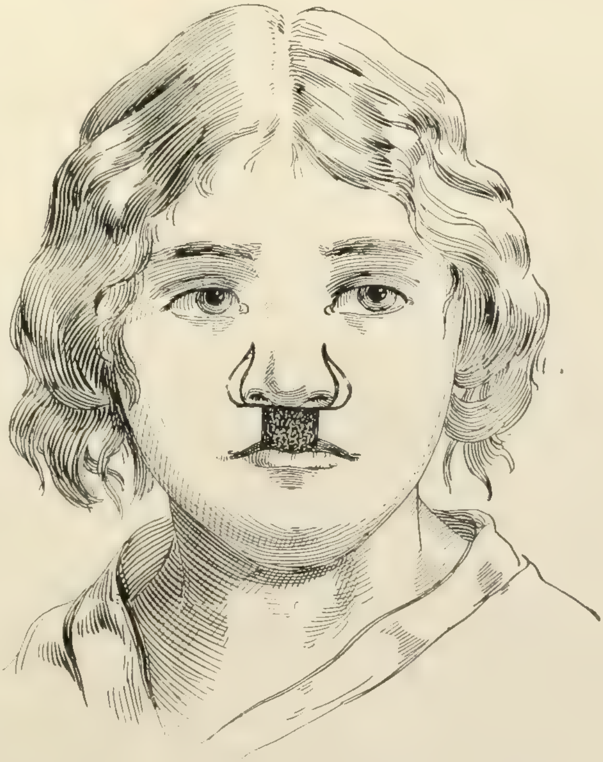


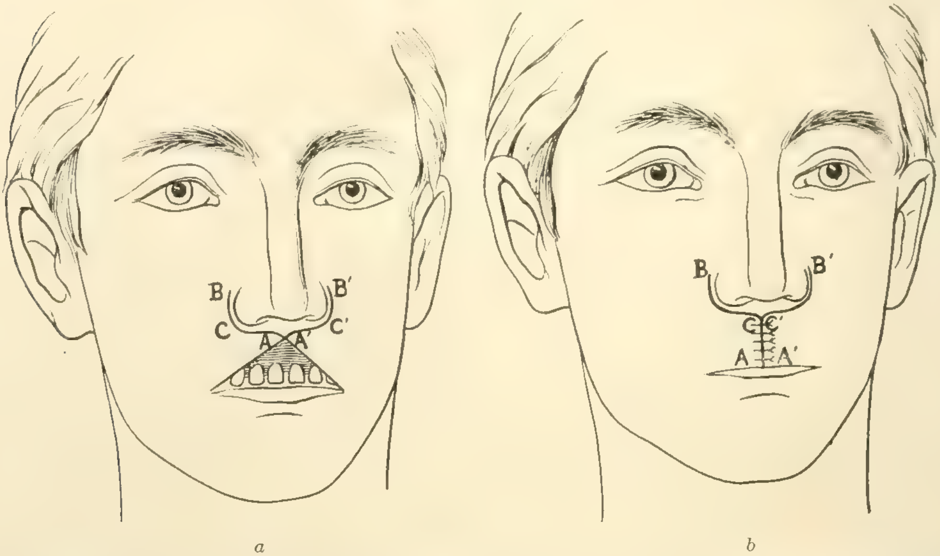
FIG. 421.—Closure of a Quadrilateral Defect of the Upper Lip by Approximation of the Sides and Excision of Crescentic Areas of the Cheek Outside Each Ala.

In certain extreme cases there is complete closure of the jaws due to extensive union between the alveolar processes and to changes in the masseter and internal pterygoid muscles. Under these circumstances it may be necessary to make a false joint in front of the cicatrix.

Upper Lip.—Plastic operations on the upper lip are required much less frequently than upon the lower. Operations for the correction of hare-lip are considered elsewhere. (See Vol. V.)

Narrow defects similar to those of congenital origin may be closed by drawing forward the tissues at the sides of the lip and from the cheeks. The operative steps in such cases are essentially similar to those for the correction of hare-lip.

Where the defect in the lip is larger and extends as a broad gap up to the nostrils, incisions may be carried from the upper border of the defect outward and upward in the fold between the ala and the cheek. A crescentic piece may then be excised from each cheek just outside the ala. In this manner the obstruction which the nose offers to the approximation of the flaps is overcome. The gaps at the sides of the nose close naturally and leave only slight scars, inconspicuous in position. (Fig. 421.)



a *b*

Fig. 442.—Shows how, in Reforming the Upper Lip, in Order to Obliterate a Triangular Gap in this Part of the Face, the U-shaped incision (*a*) around the alæ is converted into one having the shape of a Y (*b*).

In cases in which the upper outer portions of the lip below the alæ are not destroyed, the defect is more nearly triangular. Under these circumstances the incisions may be carried upward and outward from the apex of the triangular defect, curving upward around the alæ. The tissues at the sides of the defect may then be brought down to form the free border of the lip, while those points which lie at first below the alæ are drawn inward to be united in the median line below the septum. In order to gain sufficient freedom for the flaps, it may be necessary to prolong the upper ends of the incisions outward on to the cheeks. (Fig. 422.)

Wide quadrilateral gaps may be closed by drawing in, from the cheeks, flaps that have been freed by two horizontal incisions—one extending out from the upper edge of the defect, the other from the corner of the mouth. (Fig. 423.) The objections to this method are, that two disfiguring scars are made in conspicuous positions upon the cheek, and that the lower border of the new lip has no red border. The operation may be useful in loss of the entire lip.

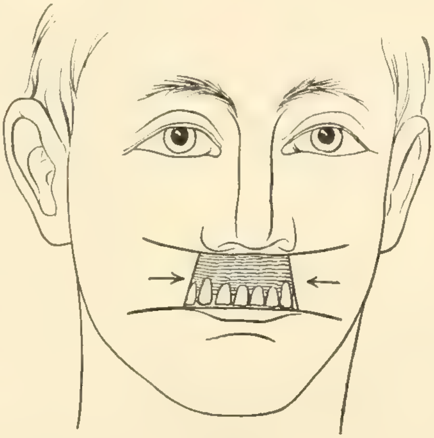
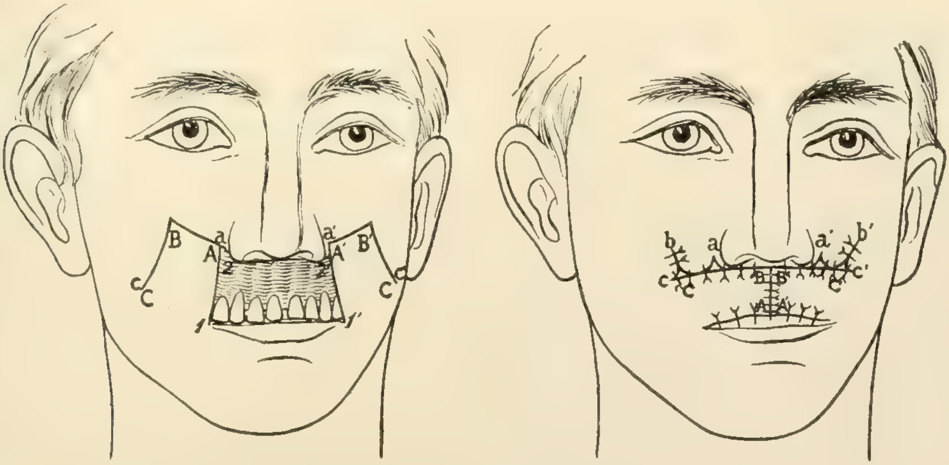


Fig. 423.

In cases in which the entire upper lip is lost, quadrilateral flaps may be cut out from the cheeks at each side of the defect. The incisions extend upward from the corners of the mouth to points just outside the alæ of the nose. (Fig. 424.) They then turn at right angles, being carried outward on the cheeks far enough to give sufficient height for the new upper lip. They then turn downward again, at right angles to the cross cut and roughly parallel with the original incisions, sufficiently far to allow the two flaps to be swung inward and to be united by their upper extremities in the median line. In those cases in which the sides of the deficiency present red borders it is well to preserve them and start the incisions higher up near the ala of the nose. Thus, tissue is saved and the ex-



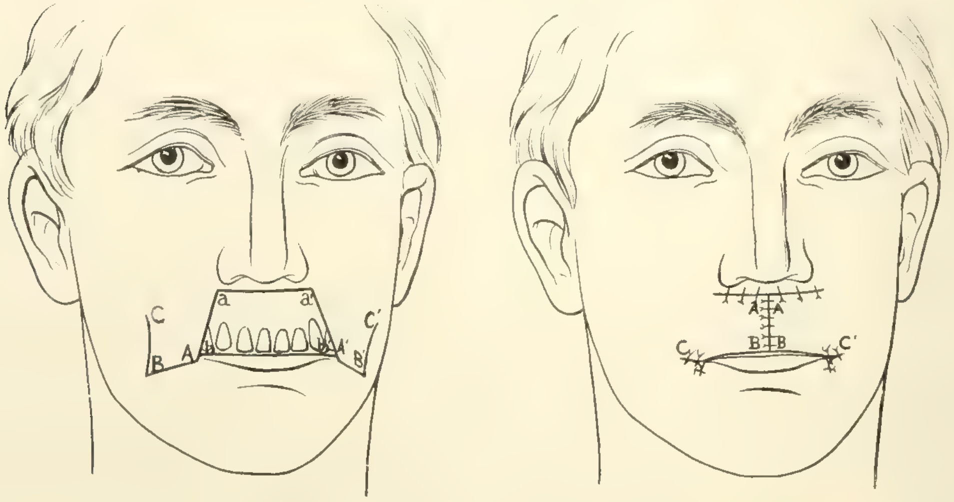
a *b*

Fig. 424.—Shows, in *a*, a Method of Remedying a Quadrilateral Defect in the Upper Lip. The incisions may start at 1 or at 2, on one side of the defect, and at the corresponding points, 1′ or 2′, on the other. They extend up along the sides of the alæ to *A* and *A*′, then turn at right angles and are carried out to *B* and *B*′, respectively, from which points they again curve downward, to *C* and *C*′. The length of the cuts *AB* and *A′B′* must be sufficient to make a lip of proper height. The manner of closing the wounds is shown in *b*.

isting red borders are utilized. Where, however, the side of the deficiency is made up of scar tissue which cannot be utilized it must be sacrificed. On the other hand, it would usually be desirable to preserve this scar tissue if possible and supply the red border at a secondary operation rather than to sacrifice it at once.

The Operation of Sédillot.—This operation is suitable for those cases in which the loss of the lip is complete.

Quadrangular flaps are taken from each side of the defect, the pedicles being above instead of below. On each side a vertical incision should start just outside the nose, midway between the corner of the mouth and the lower eyelid.



a

b

Fig. 425.—Operation of Sédillot. The incision starts at the side of the nose and is carried downward outside the cleft to a point below the corner of the mouth. It should then turn outward and a little downward (*AB*) for a sufficient distance to provide proper height for the lip. Then the incision is carried upward to *C* in *a*. In case the sides of the defect (a b, a′b′) are covered with mucous membrane they may be freed everywhere except at the corners of the mouth (b, b′) and left to be attached along the lower border of the restored upper lip, a a′ being at a lower level than *B B′* after they are united as in Fig. 425, *b*.

(Fig. 425.) It should extend downward toward the prominence of the chin. This incision sacrifices any tissue at the outer border of the defect in the upper lip unless a narrow strip of mucous membrane is left attached at each corner of the mouth to be fastened to the new lower border of the lip. From the bottom of this incision a cut is made at right angles, extending outward for a sufficient distance to give proper height to the new upper lip. An incision is then carried directly upward parallel with the original incision. The last incision may with advantage be turned slightly outward at the top. It may end at a level a little below the ala. The lower ends of the two flaps thus formed are united in the median line, the upper border of the gap being previously refreshed in order that the inner sides of the flaps may be united to it.

Those operations which leave the pedicles of the flaps below, are usually preferable to those which leave the pedicles above, because as a result of retraction of the scar there is less tendency for the flaps to be drawn upward and expose the teeth.

Gurdon Buck's Method.—Gurdon Buck,* in restoring the loss of half of the upper lip, has turned up a flap from the same half of the lower lip. The pedicle of the flap, under these circumstances, is close by the red border of the middle of the lower lip. Any mucous membrane which may be saved about the borders of the defect to be filled should be carefully reflected and utilized.

The following are the steps in the operation: The extremity of the lower lip, where it joins the cheek on the same side as the defect, is divided throughout its entire thickness, at right angles to its border, for a distance of about an inch (*A B*). (Fig. 426.) From the end of this incision a second is carried inward, parallel to the lip border, for a distance of about an inch and a half (*B C*). To facilitate the turning upward of this flap an additional cut should be carried upward from the end of the second, half way to the border of the lip (*CD*). This last incision simply narrows the pedicle and allows more freedom in moving the flap.

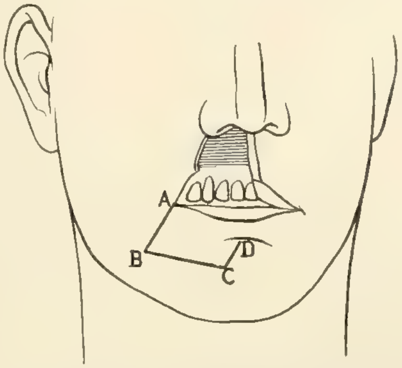


Fig. 426.—Gurdon Buck's Method of Remedying the Loss of Half of the Upper Lip.

It is necessary, at a second operation, to enlarge the side of the mouth by a transverse incision supplemented by incisions which free the mucous membrane of the upper and lower lips and allow it to be drawn outward to the corners of the new mouth.

Operations intended to restore the upper lip by the use of a flap from the forehead have been done. They are to be unhesitatingly condemned, save under most extraordinary circumstances.

Senn's Operation.—Senn (*New York Med. Jour.* and *Phila. Med. Jour.*, 1903, Vol. LXXVII., p. 1,097) has in a most ingenious manner used part of the scalp to repair an extensive loss which included not only the whole upper lip, but also the entire nose, most of both cheeks, and both lower eyelids. (Fig. 427.) The flap extended across the top of the head from ear to ear. It was wide enough to cover the entire height of the defect from the mouth to the bridge of the nose. It was left attached by two pedicles, one at each end just above the ears and including the temporal arteries. In order to guard against the risk of sloughing, Senn separated the flap in five different stages, at intervals of about a week. At these preliminary operations an extra area of skin was folded in from the middle of the forehead to line that part of the flap which was to form the new upper lip, while the other parts of the flap, which were to close in the mouth, were covered by Thiersch grafts to prevent undue contraction. When freed the flap was lowered into position exactly as the visor of a helmet is lowered. The upper and lower borders of the defects in the cheeks were refreshed and sutured to the edges of the flaps. The nasal passages were opened by transverse incisions, which were kept from closing by the use of triangular lead tubes. The hair upon those parts of the flap which were not already bald was destroyed by exposure to the *x*-rays. Additional operations were necessary to perfect the eyelids and build up a shapely nose, but the flap taken from the scalp most successfully closed the great gaps in the upper lip and cheeks which had left the whole mouth exposed. (Figs. 427 and 428.)

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* "Reparative Surgery," Appleton & Co., New York, 1876.

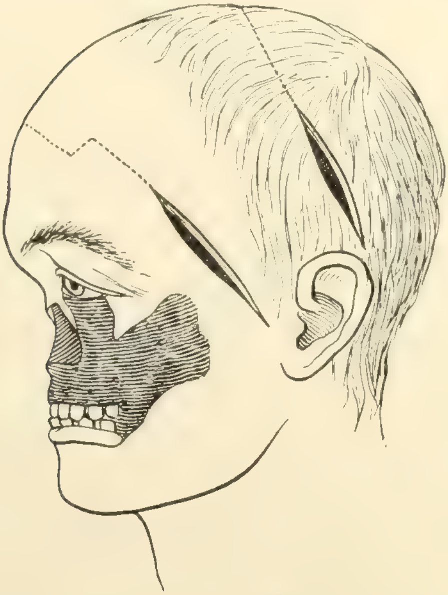


Fig. 427.

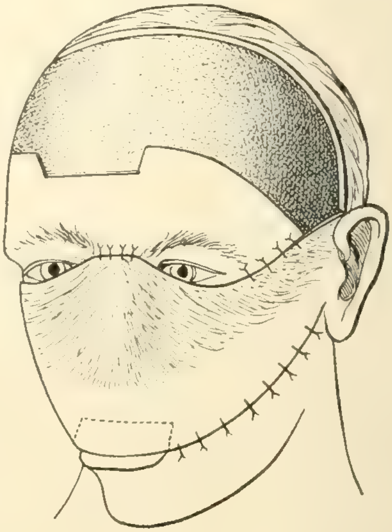


Fig. 428.

Fig. 427.—Operation of Senn. Shows the extent of the destruction and indicates the incisions made at the first operation. The dotted lines indicate the complete incisions. The extra piece of skin taken from the middle of the forehead was used to line the new upper lip.

Fig. 428.—Shows the Flap Lowered into Place and Sutured to the Freshened Borders of the Defect. The incisions into the nasal cavity are not yet made.

Lower Lip.—Most of the defects in the lower lip which need to be restored are the result of the excisions of epitheliomata. Some are the results of other causes, chiefly accidents.

Fortunately, in many cases the gap to be filled is relatively small. In all cases where it is going to be possible to bring the edges of the gap together directly, without the formation of any flaps, the gap should be converted unhesitatingly into a V-shape. This may usually be done advantageously where the mucous membrane at the corners of the mouth is not involved. When the corners of the mouth are destroyed, some more extensive interference is generally necessary. The chief advantage of direct suture is that there will remain only a single linear scar which, in a man, may be concealed by the beard. The elasticity and power of adaptation of the tissues about the mouth are remarkable.

In cases in which liberating incisions are necessary, the more simple the cuts made the better. They should, wherever possible, follow the natural lines of the features. Thus, in those cases in which direct union is not possible, the procedure of choice is the making of a curved incision from the corner of the mouth on each side outward and then downward, in order that the flap thus formed may glide inward to meet its fellow of the opposite side. (Fig. 429.) This procedure is usually as effective as, and less disfiguring than, other more formal operations which depend on the same principle. Nevertheless, it may be well to describe briefly the operations of Serre, Jaesche, Dieffenbach, and Heurtaux, all of which are adaptations of the principle of sliding together lateral flaps freed by incisions carried outward from the corners of the mouth.

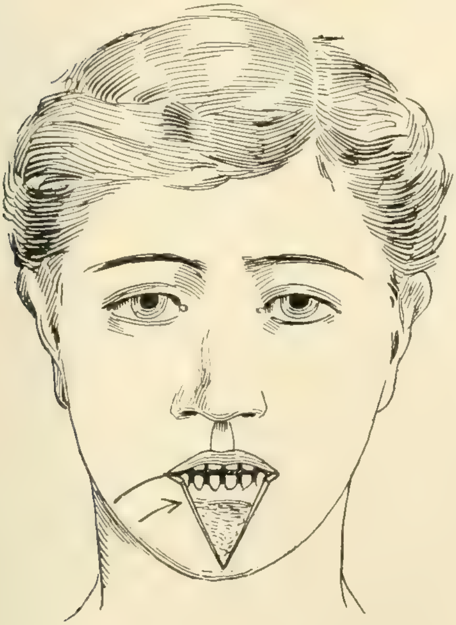


Fig. 429.

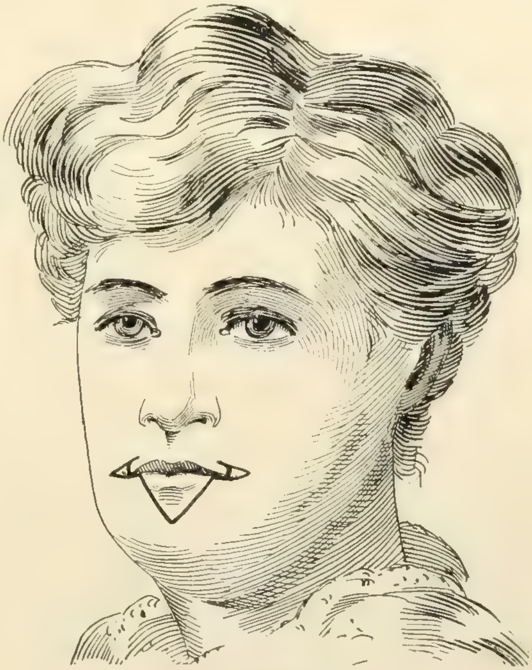


Fig. 430.

Fig. 429.—Liberating Incision Extending Outward from the Corner of the Mouth.

Fig. 430.—Operation of Serre. In order to restore the width of the mouth a small piece of cheek may be excised on each side. At the same time it is important to preserve carefully the mucous membrane at the corner of the mouth.

In all operations it is essential that the mucous membrane should be stitched to the skin at the edges of the lip. It is especially important for the comfort of the patient, and to prevent cicatricial contraction, that no gaps be left uncovered in the new corners of the mouth. Before any incisions are made with a view to mobilizing flaps it is very important, first, to reflect and save any mucous border which would otherwise be sacrificed. Then, in the next place, in planning the incisions one must estimate whether the closure of the secondary gap will—if no allowance be made—cause distortion or asymmetry.

OPERATION OF SERRE.—A longitudinal incision is made directly outward from the corner of the mouth on each side. In this way the tissues at each side of the V-shaped gap in the lip are mobilized so that they can be brought together. The mucous membrane is sutured to the skin on each side, thus restoring the red border of the new lower lip and corners of the mouth. The width of the mouth is restored. In order to give space between the upper and lower lips at the corners of the mouth it is often necessary to excise a small amount of tissue along the lines of the liberating incisions; but, if this is done, the mucous-membrane border should first be reflected from below upward in order that it may be utilized to cover in the new edge of the lip as far as is possible. (Fig. 430.)

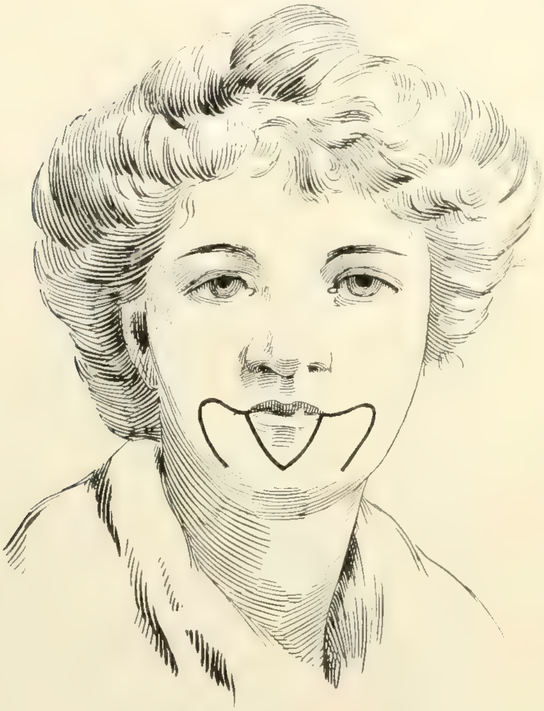


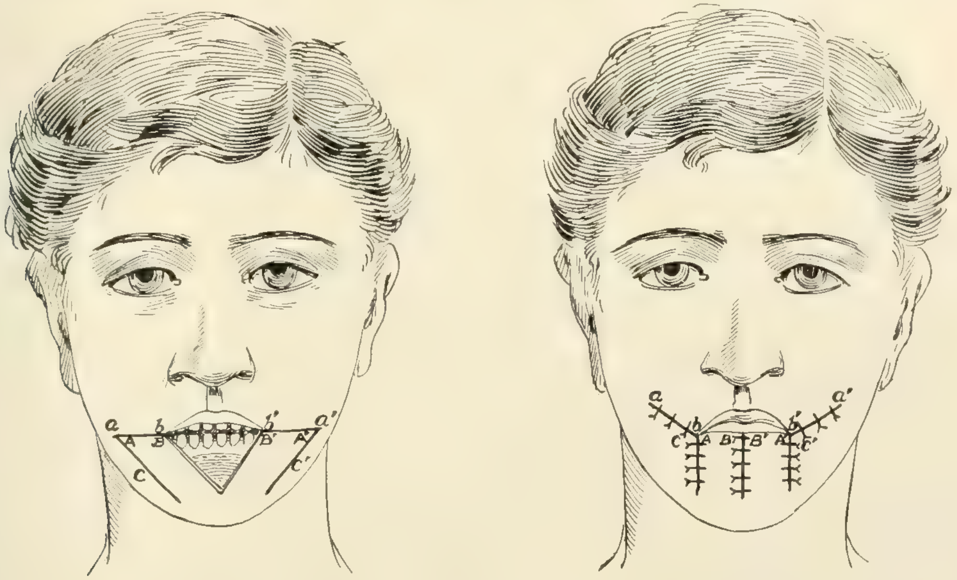
FIG. 431.—Operation of Jaesche.

This operation leaves the lower lip drawn much more tightly than the upper, which is of course somewhat puckered forward.

When it is found that sufficient freedom is not obtained by the simple lateral incisions of Serre, they may be prolonged according to the method of Jaesche or of Dieffenbach.

OPERATION OF JAESCHE.—In this operation a more extended V-shaped deficiency may be closed by extending the incisions from the corners of the mouth outward and a little upward, and then, with a rather sharp curve, cutting downward in lines parallel with the sides of the V and reaching as low as the apex of the V. Thus two flaps are formed which may be swung inward to unite in the median line, while the gaps left at the sides may be closed by uniting the upper and outer edges. (Fig. 431.)

OPERATION OF DIEFFENBACH.—A horizontal incision is made on each side through the cheek directly outward from the corner of the mouth. The combined length of the incisions should equal the width of the mouth. From the outer ends of these incisions cuts are carried downward and inward parallel with the sides of the V-shaped gap in the lip. The two rhomboid flaps (*CAB* and *C′A′B′*) thus formed are swung inward and united in the median line. (Fig. 432.) The mucous membrane should be sutured to the skin at the border of the new lip. The two triangular gaps are closed by suturing the upper to the outer sides. The operation resembles closely that of Jaesche, except that the flaps have angular instead of rounded corners. As in the other operations, it is essential to suture the mucous membrane of the upper lip accurately to that of the lower lip at the corners of the mouth. In order to do this satisfactorily it is often of great help to free somewhat the mucous membrane of the upper lip at the two sides and draw the mucous flaps thus formed toward the middle of the lower lip. This step prevents cicatricial contraction of the new mouth, and adds greatly to the comfort of the patient when fed.



a *b*

FIGS. 432.—Operation of Dieffenbach. *a*, Method of cutting the flaps; *b*, the flaps united.

HEURTAUX'S OPERATION.—In Heurtaux's operation * a single flap is formed by carrying an incision in a long curve outward and downward from one corner of the mouth. This flap is then swung upward and forward across the defect and united to the edges of the gap at the other side. In order to prevent puckering in the skin on the convex side of the curve a triangular area may be excised just below the jaw. (Fig. 433.) The operation is not well adapted to cases in which the gap involves more than one side of the lower lip. On the other hand, the direction of the incision which frees the flap opens up the region of the submaxillary lymph-nodes, while the triangular area of skin which may be resected is taken directly from the region of these nodes. Under ordinary circumstances the excision of this triangular area of skin may be obviated by a simple curved prolongation of the incision backward, thus making the whole incision have an S-shape.

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* Archives Provinciales de Chirurgie, 1893, vol. ii., p. 747.

MALGAIGNE'S OPERATION.—In quadrilateral defects of moderate extent the procedure of Malgaigne* is often satisfactory. (Fig. 434.) Horizontal incisions are carried outward from each corner of the defect—one from the corner of the mouth and one from the lower angle of the defect on each side. Thus, at the sides of the gap, there are raised two flaps which may be drawn inward to unite in the median line. Often it will be found that this procedure draws the new lip very tightly, especially at the lower part.

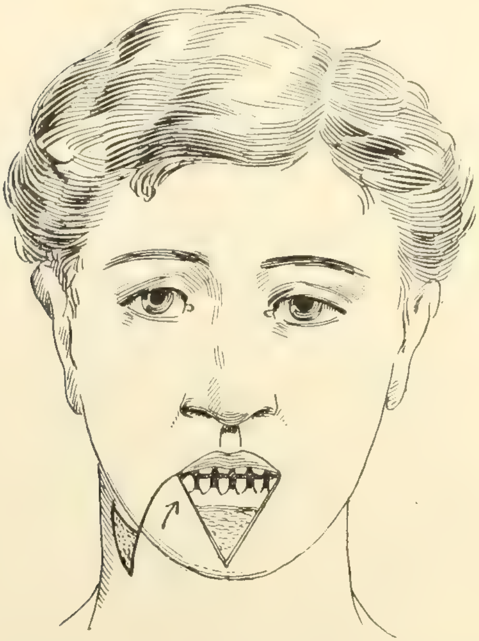

FIG. 433.

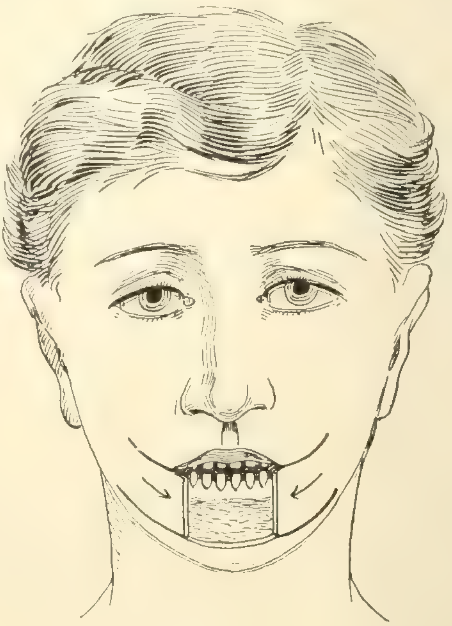

FIG. 434.

FIG. 433.—Heurtaux's Operation. The figure shows resection of a secondary area of skin to allow accurate apposition of the flaps. Access is given to the submaxillary lymph nodes.

FIG. 434.—Operation of Malgaigne.

The conditions which must be met are so varied that a thorough understanding of the various other methods is necessary before one decides to give Malgaigne's the preference. Flaps may be taken from the chin. The operations of Syme, Buchanan, and Trélat are the types of this group. They all depend upon jumping a flap from the side to a point above the central prominence of the chin. It is essential to the success of all the operations of this group that the tip of the chin remain undisturbed in its attachments to the jaw.

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*Malgaigne: "Médecine Opératoire," vol. ii., p. 209.

Where flaps are taken from the chin the absence of an inner mucous surface is likely to lead to a formation of firm adhesions between the jaw and the flap, and these adhesions may interfere to a great extent with the functional usefulness of the new lower lip.

Operation of Syme.*—Where the whole lower lip has been removed, leaving a V-shaped gap to be filled, two flaps are raised from the sides of the chin. This is done by prolonging the original cuts which removed the lip. These incisions thus cross above the prominence of the chin which is left undisturbed. The length of these prolongations of the incisions should equal the length of the incision from the corner of the mouth to the point at which they cross. The incisions should then turn at a sharp angle and run upward and backward to form rhomboid flaps which may be united in the median line directly above the prominence of the chin. (Fig. 435, *a*.) The triangular flaps are closed by suturing the inner and outer sides together from the bottom, if this is possible, but usually the gap must be united horizontally. (Fig. 435, *b*.)

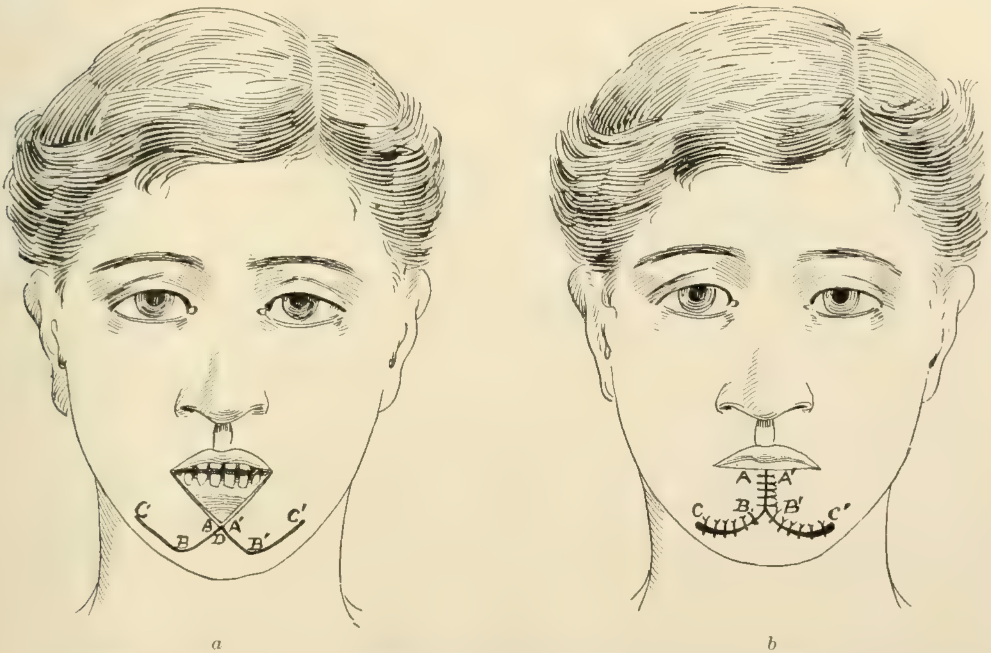

Fig. 435.—Operation of Syme. *a*, Method of cutting the flaps; *b*, the flaps united above the undisturbed prominence of the chin.

Operation of Buchanan.—Buchanan's operation differs in no essential respect from that of Syme. The incisions are curved instead of angular. The excision of the lip is done by a U-shaped instead of a V-shaped incision. The incisions for freeing the flaps pass downward and outward, and then curve upward and backward. Owing to the form of the incisions the gaps left are closed horizontally.

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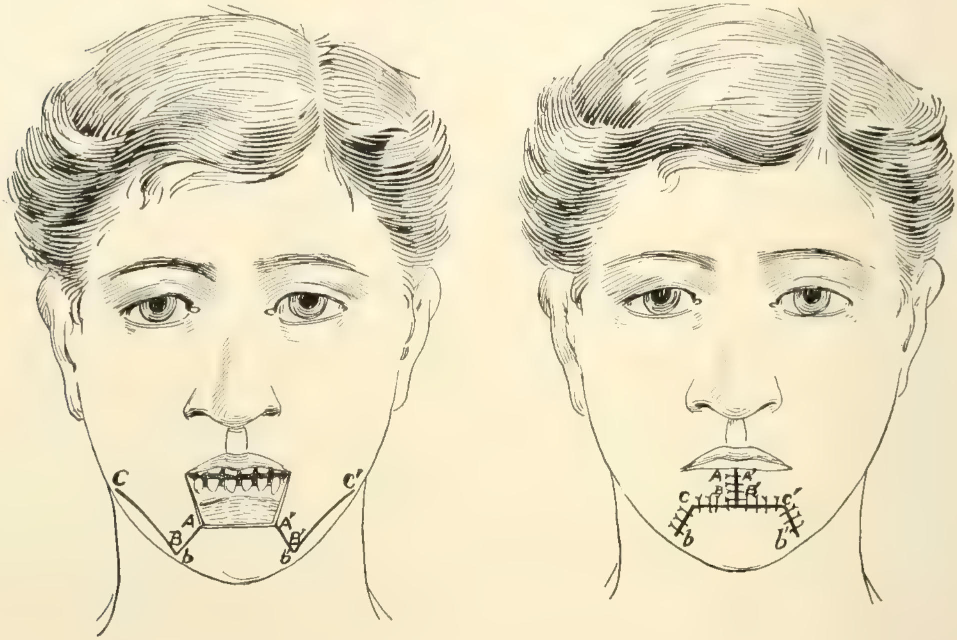
* "Observations in Clinical Surgery," p. 60, Monthly Journal of Medical Sciences, Edinburgh, 1846–47, p. 643.

Neither of these operations can be used in those cases in which the prominence of the chin is lost. The normal relation of this prominence to the jaw is essential to success. The new lower lip must have this point of support below to prevent it from being drawn downward.

Operation of Trélat.*—The operation of Trélat, based on exactly the same principles as those of Syme and Buchanan, differs from them only in the fact that the area of skin left on the point of the chin is quadrilateral and broad at the top rather than triangular and pointed. (Fig. 436.)



a *b*

Fig. 436.—Operation of Trélat. *a*, Incisions required; *b*, the flaps united.

Similar in principle to the bilateral operations just mentioned is the unilateral Operation of Langenbeck, in which a quadrilateral flap is taken from below the point of the chin, the pedicle being just below the corner of the mouth. Where there is a choice, the pedicle should be on the side where the deficiency is least. It is essential that an area of sound skin be left between the deficiency and the flap which is to fill it. The flap is to be jumped above this area of skin and sutured into position to form the new lip, while the gap left is to be closed by drawing the edges together laterally. (Fig. 437.)

Operation of Blasius.—This operation is useful only in broad triangular defects which do not extend far down upon the chin. The flap is taken from one side or the other. From the apex of the triangular gap a cut is made in direct continuation of the shortest side downward into the submaxillary region. (Fig. 438.) The flap thus marked out is to be freed and slid upward to form the new lip. The objections to the operation are: that the flap inevitably tends to draw downward again into its old position, thus leaving the lip deficient; and besides, if the gap extends at all into the region of the chin, the flap will be without mucous membrane on its inner surface.

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* Bulletin de la Société de Chirurgie, February 28th, 1877, p. 170.

Berg's Operation.*—This is an elaboration of the operation of Blasius, and is intended to fill larger gaps in the lower lip. The incision is made down into the submaxillary region as a direct continuation of the shortest side of the gap to be filled. The cut should curve slightly toward the median line. The length of the incision should equal the height of the gap to be filled. The incision should then curve sharply backward, in a direction roughly parallel with the side of the gap. Thus, a flap is formed which may be more freely raised into position, while the triangular space left below may be closed by suturing each of the three angles. (Fig. 439.)

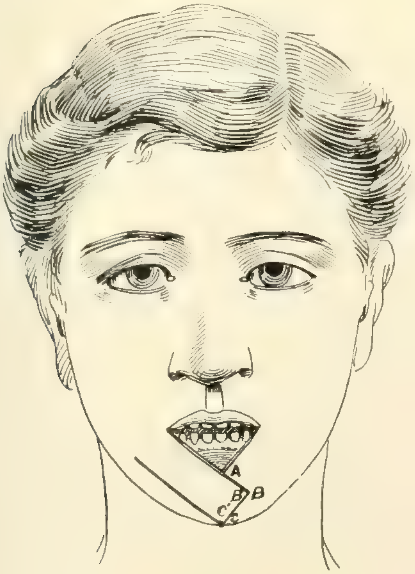

Fig. 437.

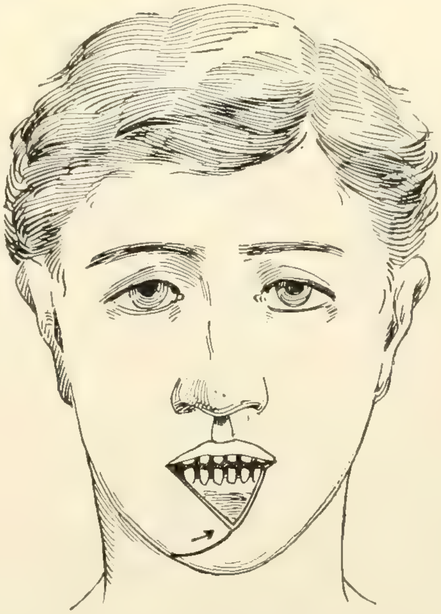

Fig. 438.

Fig. 437.—Operation of Langenbeck. An incision *A B* is carried from the lower angle of the gap to a prolongation of one of its sides. The distance to *B* should be enough to enable *B'* to be attached to the corner of the mouth. A second incision *B C* is carried down at right angles to the first, and from *C* a third incision is made parallel with the first. *C'* is united to *A*.

Fig. 438.—Operation of Blasius.

This operation, while it is not open, as much as some other operations, to the serious objection that the flap may undergo retraction, is very liable, owing to the complete absence of the mucous lining, to be followed by the formation of cicatricial adhesions between the lower jaw and the flap, and subsequently by contraction of the latter.

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* Malgaigne's "Médecine Opératoire," vol. ii., p. 206.

There are two other operations which should perhaps be mentioned, although chiefly for the purpose of condemning them—viz., Chopart's and Sandelin's operations.

Operation of Chopart.—This operation has been used in closing a quadrilateral defect in the lower lip. Incisions are carried downward to below the jaw in direct prolongation of the sides of the gap to be filled. The flap thus freed is drawn up to make the new lip. This operation is objectionable in that it violates one of the fundamental principles of plastic surgery: it fails to make a change in the direction of the flap and also to furnish it, when in position, with a proper support. The result is that the skin inevitably draws down, and the original deformity is reproduced. Prolongations of the incisions backward may free the flap a little, but not sufficiently to be of material benefit.

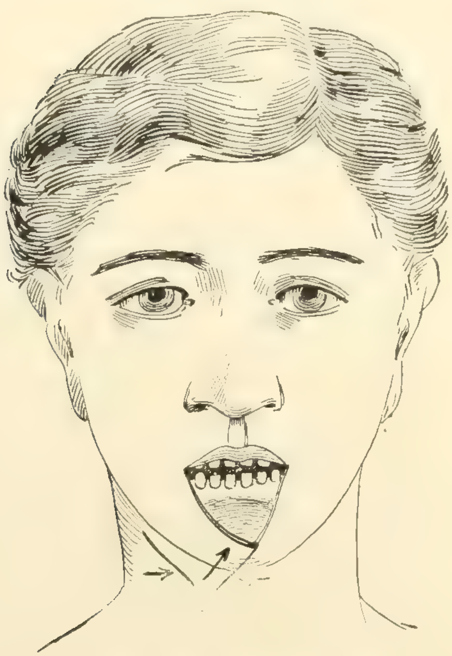

Fig. 439.—Operation of Berg.

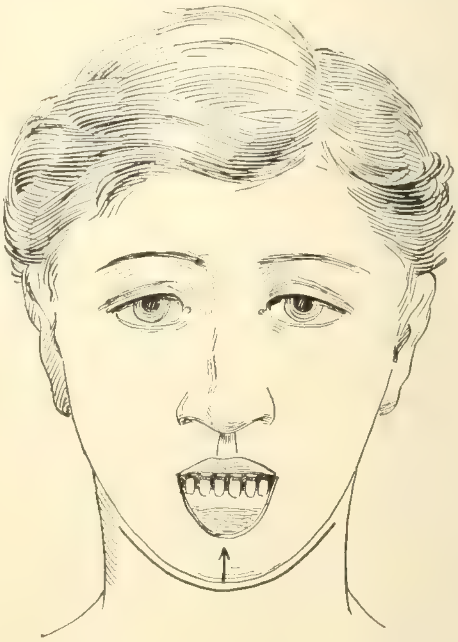

Fig. 440.—Operation of Sandelin.

Operation of Sandelin.—The operation of Sandelin (Schulten-Morgan) is open to much the same objection as is Chopart's. Owing to the fact that the skin is slid along without change in direction, there is great tendency to reproduction of the deformity as cicatrization progresses. Where the whole lower lip is gone, a crescentic incision, roughly parallel with the borders of the defect in the lip, is made under the chin. The ends of the incision should be below and outside the corners of the mouth. The width between the incision and the defect should be sufficient to reach from the mouth to below the prominence of the chin. The flap thus formed is to be left attached only at the two ends. (Fig. 440.) When freed from the jaw it is to be slid upward and forward into position to form a new lip, and is to be fastened to the jaw to prevent it from sliding back until it shall have become firmly adherent in its new position. The defect left below is to be sutured from side to side as far as is possible, in order to minimize cicatricial contraction.

While the portion of the operation which has just been described is not to be recommended, the second part is most ingenious and is capable of application to many other operations. A strip of the mucous membrane and underlying tissues along the lower inner surface of the upper lip is cut free except at the two ends. This ribbon of mucous membrane is then twisted and also drawn downward and sutured to the border of the newly formed lower lip, while the gap in the upper lip is closed by suture also. Thus the superfluous mucous membrane of the upper lip is utilized in such a way as to form a new red border for the lower lip.

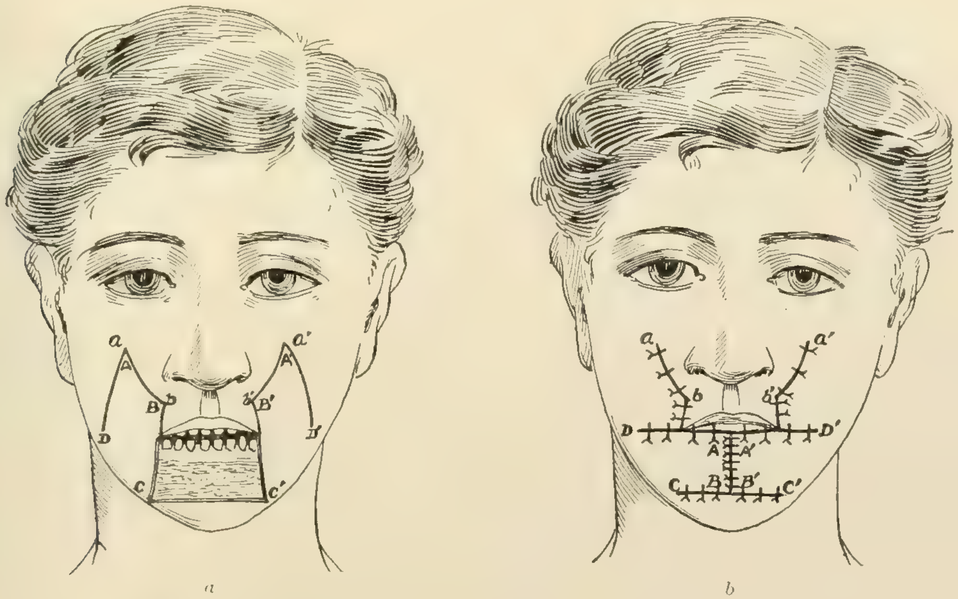

FIG. 441.—Operation of von Bruns. *a*, The defect in the lower lip and the lines of the incisions are shown in this figure; *b*, the flaps have been brought into position and sutured.

There are certain fundamental objections to taking flaps from the chin. Wherever possible, it is important that flaps should include skin and mucous membrane. The mucous membrane does not extend down upon the chin. Thus the flaps have to heal by granulation on their posterior surfaces, with the result that they contract and often become so bound down to the lower jaw as to interfere with their usefulness. Furthermore, the flaps are taken from the immediate vicinity of the region in which the defect already exists. Thus there must be either great tension of the parts or an insufficiency of the new lip.

To obviate these difficulties flaps have been taken from the upper lip and adjacent parts of the cheek, very frequently with most gratifying results and surprisingly little scar.

Operation of von Bruns.—von Bruns' operation for closure of a defect of the lower lip is the exact counterpart of the Malgaigne-Sédillot operation for closure of a defect in the upper lip.

The operation is particularly applicable to those cases in which the portion of the lower lip removed has been very broad below. It has the further point to recommend it that the resultant scars follow the lines of the naso-labial folds. When the entire lower lip has been removed, leaving a quadrilateral gap to be filled, the lateral incisions are prolonged upward and inward from the corners of the mouth to points directly below the alæ of the nose. (Fig. 441.) Parallel incisions, separated from the first incisions by a distance sufficient to give proper height to the new lip, are to be made in each cheek. The upper ends of the two incisions are to be united by a cut made at right angles to the two sets of incisions just described. In cases in which additional depth of the new lip is required in the median line, a little extra tissue may be gained by making the connecting incision follow the edge of the ala nasi and extend upward a little at the border of the nose, rather than by carrying it straight across at right angles to the other incisions.

In cases in which it is possible, the corner of the mouth is to be preserved, and at all events every possible bit of mucous border is to be left attached to the upper lip in order that it may be freed and brought down to cover in the edge of the newly formed lip.

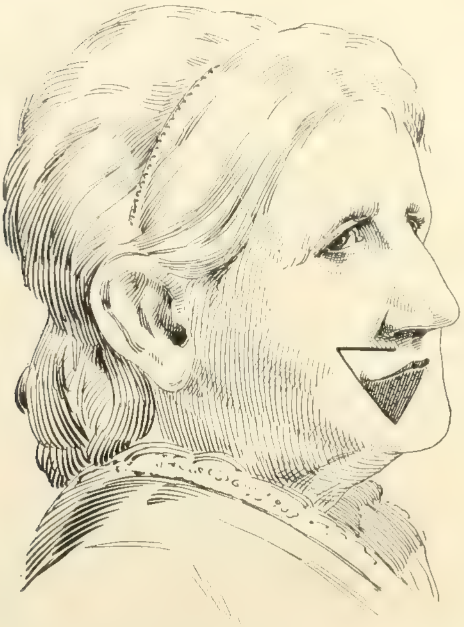

Fig. 442.—Operation of Estlander. The pedicle of the flap lies toward the middle of the upper lip. It includes enough skin and mucous membrane to insure adequate nutrition. The first incision upward and outward from the corner of the mouth at the edge of the gap should equal in length the height of the gap. The inner border of the flap is to be of the same length.

Operation of Larger.—In principle this operation is similar to that of von Bruns. The flap is unilateral, instead of bilateral. The operation is, therefore, particularly applicable to those cases in which the gap involves chiefly one side of the lip. The mucous membrane from the sound side may usually be drawn across the flap to complete the red border.

OPERATION OF ESTLANDER.—Estlander's method of filling a wedge-shaped gap in the side of the lower lip by swinging down a triangular flap from the upper lip is often most useful and may be applied to the correction of deformities about the corner of the mouth. (Fig. 442.) The flap thus turned into the gap is left attached toward the middle of the upper lip. The apex of the flap should lie upward and outward. When swung into position the flap should be made as wide as possible by suturing together directly the lower parts of the sides of the defect, the flap being reserved to fill the upper part. The resulting scar will thus have a Y- instead of a V-shape. The gap in the upper lip may be closed by direct suture.

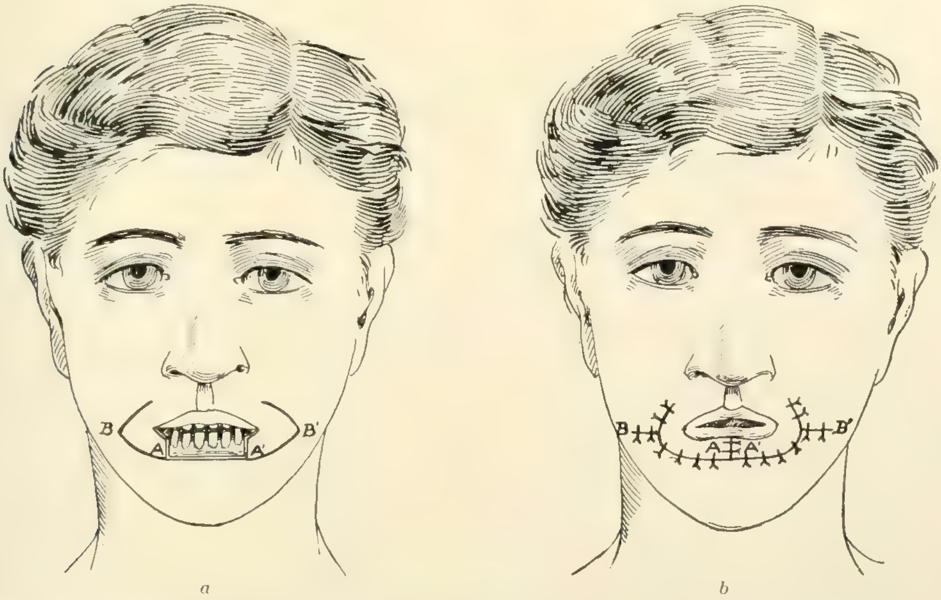

FIG. 443.—Second Operation of Langenbeck. *a*, Shows the lines of the incisions; in *b* the flaps are in position and the edges of the wound have been sutured.

The chief objection to the operation is the liability of inversion of the flap. This is due chiefly to its thickness. If hairs grow on the inverted area they may give much annoyance.

SECOND OPERATION OF LANGENBECK.—Another operation of Langenbeck utilizes a principle which is of the utmost importance in the surgery of the mouth. It depends entirely upon the elasticity and vascularity—what might be termed the plasticity—of the borders of the mouth. The operation consists simply in incisions which encircle the corners of the mouth, thus making it possible to approximate the sides of the gap. The mouth is of course narrowed by exactly one-half the breadth of the deficiency. The elasticity of the tissues is such, however, that this loss is soon compensated; and, furthermore, the corner of the mouth soon becomes properly moulded into its new location. (Fig. 443.)

It is a matter of considerable importance that the technique and advantages of this operation should be fully understood, because modifications of it may be used constantly in combination with other operations. In the first place, when the gap in the lower lip has much height, the operation in question cannot be utilized unless it is to be combined with other procedures. Under other conditions, however, the only limitations to the operation are the too great narrowing of the mouth and the risk of impairing the circulation at the tips of the flaps.

OPERATION OF MAUCLAIRE.—Mauclaire (*La Tribune Médicale*, Jan. 23d, 1904, p. 53) has described an operation in which he was obliged to remove the entire lower lip and the skin below it which covered the diseased submaxillary lymph nodes. In order to fill the gap thus made he turned in a flap the pedicle of which was located below, at the side of the defect, while the body of the flap extended over the sterno-mastoid muscle and terminated up on the mastoid process. Thus the tip of the flap, which goes to make up the front of the lower lip, may be covered with hair. (Fig. 444.)

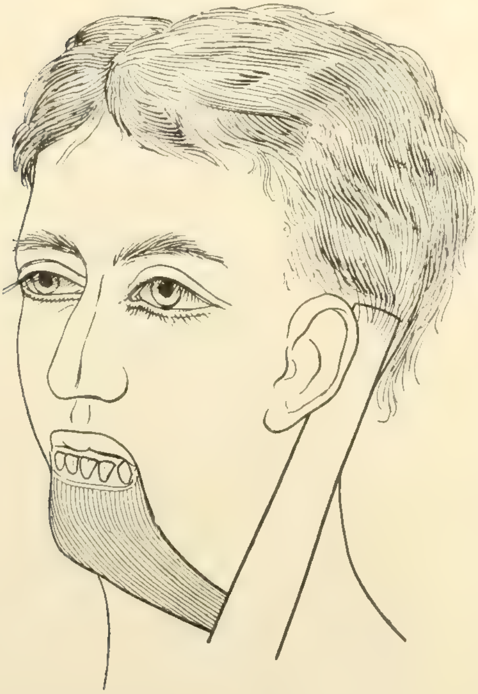

FIG. 444.—Operation of Mauclaire. A flap from the mastoid region is transferred to the chin and lower lip.

OPERATION OF ALFRED C. POST.—Alfred C. Post (Ashhurst's "International Encyclopædia of Surgery," Vol. V., p. 474) has suggested that deficient mucous membrane in the lips may be supplied by folding a flap of skin up from the neck through a slit cut along the border of the lower jaw, just as is done in operations upon the cheek. He has further suggested the possibility of transferring a flap of skin from some distant part of the body, attaching it first to the wrist and later transferring it to the mouth.

OPERATION OF WATTS.—Watts* has operated on a case in which the entire loss of the lower lip was supplied by an adaptation of the Italian method. A flap, including the skin and subcutaneous fat, was dissected up from the right upper arm. The under surface of the flap was covered with Thiersch grafts, so that at the end of ten days the flap was covered with skin on both sides. At a subsequent operation the flap was sutured into position and the arm was held in a plaster cast for about three weeks. Under local anæsthesia the flap was gradually separated in order that the circulation might not be completely cut off at one time. At subsequent operations the flap was trimmed and sutured accurately into position.

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* Bulletin of the John Hopkins Hospital, vol. xvi., p. 109.

This operation has a strong point in its favor in that it causes no further mutilation of any other part of the face or neck. A very serious objection to the operation is the tremendous contraction which the flap undergoes while the grafts are growing, in the interval between the time when it is freed and the time when it is sutured into position.

In determining the type of plastic operation to be adopted in any individual case, the factors which must be considered are the extent and shape of the loss of substance and, more especially, the necessity for additional incisions in order to reach the lymph nodes of the neck. In planning an operation it may often be possible to make these secondary incisions serve the double purpose of giving access to the triangles of the neck and also of freeing flaps to fill the deficiencies.

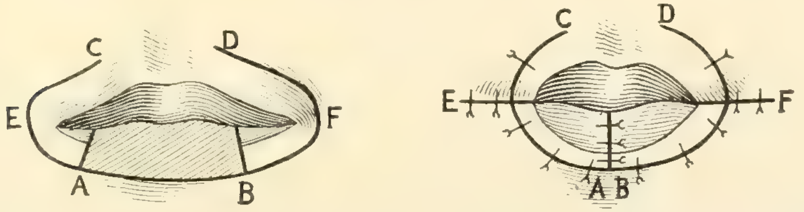

Fig. 445.—Esmarch's Operation for Restoring the Red Border of the Mouth. Incisions *A E C* and *B F D* surround the mouth, the flaps being left attached at the common pedicle *C D*. The position of the pedicle would obviously vary with the location of the gap.

One must also bear in mind the possibility of being obliged, while dissecting out lymph nodes, to tie vessels which may impair the nourishment of the flaps as planned.

Certain conditions must be fulfilled in a successful cheiloplasty. First, there must be a mouth of proper size which can be opened and closed easily. The teeth must be covered and the lips must prevent any escape of saliva or food during mastication. The lips must as far as possible be restored to their normal shape, and they should have a red border and an inner surface of mucous membrane throughout at least a moderate height, in order to prevent firm fixation to the jaw. Furthermore, the disfigurement secondary to the restoration of the lips must be inconspicuous.

Restoration of the Mouth.—Extreme narrowing of the mouth may follow cicatricial contraction due to burns or ulcerative processes about the lips. Occasionally it may be necessary to enlarge the mouth as a secondary operation after the removal of very large epitheliomata. Oftentimes there may exist at one portion of the mouth sufficient red border, if properly treated, to be utilized in encircling the whole mouth. Under these conditions the ends of the sound mucous border are to be separated by incisions reaching to a central pedicle. In this manner the two ends may be freed and united at a point opposite the pedicle. (Fig. 445.)

Where the opening of the mouth is very small two lateral incisions, extending through the whole thickness of the cheek, are carried directly outward from the angles of the mouth far enough to make the mouth of proper width. The mucous membrane is then sufficiently separated to allow its being stitched to the skin all around the new opening. It may be wise in these cases to cut away, where it exists, a considerable portion of the subcutaneous fat, and where there is any superfluous skin it may be cut away to some extent in order to bring into slightly greater prominence the new mucous border. It is especially important that the skin and mucous membrane be united at the angles of the new mouth. If primary union is not secured at this point, renewed contraction of the opening will certainly follow. It is well at the corner of the mouth to divide the incision in the mucous membrane into a horizontal Y, in order that the small triangular flap thus formed may be stitched to the skin at the corner of the mouth. This procedure is exactly analogous to that used in operations for webbed fingers. In carrying the incision outward from the cheek it may often be wise to make the cut through the mucous membrane at a level a trifle higher than that through the skin, as thereby a little more mucous membrane would be brought into view on the lower than on the upper lip, and the normal relations would be more closely imitated.

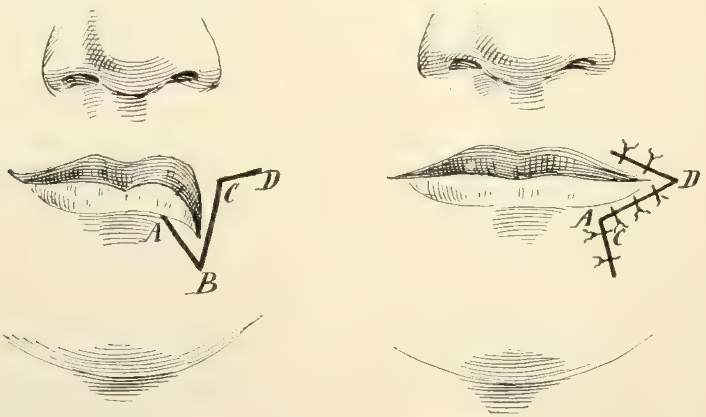

FIG. 446.—Method of Restoring to its Normal Shape the Deformed Corner of the Mouth. The flap *A B C*, which is left attached by the red border at *A*, where the distortion ceases, and by the space between *C* and the mouth, is transferred to the slit *CD*.

In certain cases it is necessary to restore a corner of the mouth, which has been distorted by cicatricial contraction, to its normal shape and position. The operation of choice in these cases must depend on circumstances. Where the mouth is of normal size and is lined by normal mucous membrane, which, however, has become distorted by cicatricial contraction of the tissues about it, the operation of choice would be the sliding in of a flap to fill the gap left by the excision of the contracted tissues. More generally, however, the tissues of the borders of the mouth are injured as well as those of the lips. Under these circumstances it is necessary to alter the size and borders of the mouth itself by the transfer of a flap. This may be done by a V-shaped incision around the deformity, combined with an incision—or, if necessary, a V-shaped excision—extending out into the cheek, to change the position of the corner of the mouth. (Fig. 446.)

Eversion of the red border of the lip may be corrected by freeing the mucous membrane by an incision carried exactly along the line where it joins the skin. After the border of mucous membrane is thoroughly free, so that it may resume its normal position, the skin should be brought in to support it. If no other operation seems more feasible, this may be done by carrying downward, from the edge of the skin below the middle of the gap, two curved diverging incisions. The central prominence of the chin lies between the incisions. (Fig. 447.) The parts of the lip outside each of the incisions is split by undermining the skin, care being taken to avoid injury to the mucous membrane. The two flaps of skin thus formed are moved upward and inward to be united to each other in the median line above the undisturbed prominence of the chin. In cases in which the ectropion of the lip is unilateral only one flap need be raised.

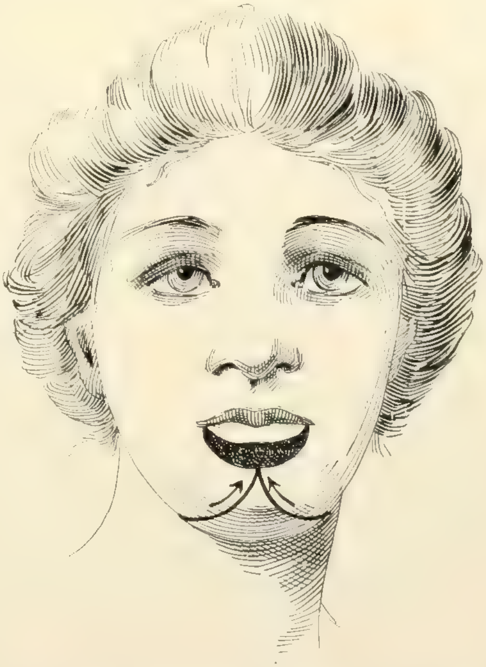

Fig. 447.—Correction of Eversion of the Red Border by Bringing up Supporting Skin Flaps to Hold the Freed Mucous Membrane in Place.

Operation of Serre.—In cases in which there is widespread destruction about the corner of the mouth, Serre has devised a method of filling the gap by quadrilateral flaps freed for a sufficient distance to make it possible to draw them across the defect. The extent and number of the incisions made must depend on circumstances. (Fig. 448.)

The Eyelids.—While most plastic work upon the eyelids falls within the province of the oculist, the surgeon must nevertheless understand the principles which govern the general procedures, and very frequently he will be called upon to perform plastic operations in cases in which the external surface of the lids has been lost by ulceration or through the removal of new growths, or in cases in which the lid is drawn out of shape by cicatricial contractions of the external surface.

Those forms of ectropion which require for their correction the resection of the conjunctiva, correction of the tarsal cartilage, or shortening of the edge of the lid belong distinctively to the oculist and will not be discussed here. There are, however, many cases of ectropion which require a plastic operation upon the skin alone.

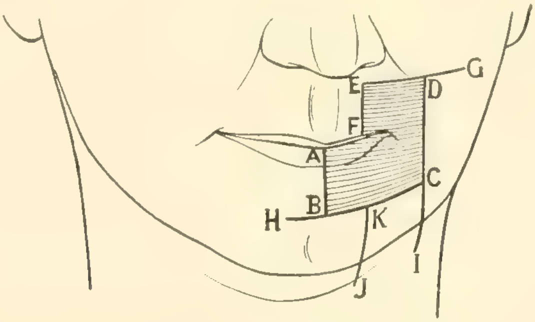

FIG. 448.—Operation of Serre. In order to fill the defect *ABCDEF*, an incision *D G* is carried outward from the upper border of the defect on to the cheek. A second, *B H*, is carried inward on to the chin from the lower border of the defect. Two others are carried downward, one, *C I*, from the lower outer corner of the gap, and another, *K J*, parallel to, and as far inside of the first as the upper portion of the gap is wide (distance should equal *ED*).

The flap from the outer part of the chin, *JKCI*, if sufficiently undermined, may be drawn upward to meet the upper border of the defect, *DE*. The flap from the median part of the chin, *HBA*, may be drawn outward upon the cheek to the outer border of the gap, *CD*. The flap *GD C* from the cheek may be drawn inward somewhat to help fill the gap. If all of these incisions prove unnecessary, some may be omitted.

Ectropion due to cicatricial contraction of the skin of the lid may, in the milder cases, be corrected by very simple measures. In any event, however, all cicatricial tissue must be removed.

THE OPERATION OF BONNET consists in making a transverse slit through the skin slightly below the edge of the lid, undermining the edges of the incision, and suturing the wound perpendicularly.

THE OPERATION OF WHARTON JONES is usually to be preferred, however, to that of Bonnet, and in those cases in which the cicatricial tissue is limited in extent, causing only a partial ectropion, it is usually the method of choice. A V-shaped incision is made immediately below the cicatrix. The arms of the V embrace the scar and reach nearly to the edge of the lid. The scar is separated from the underlying tissues and is pushed upward. The skin at the outer sides of the V is undermined to a slight extent. The incision is then closed by sutures in such a manner that it is converted into a Y.

THE OPERATION OF GUÉRIN.—Guérin has devised a more complicated and less satisfactory operation for the correction of ectropion—an operation, however, which may be useful in exceptional cases. He makes an incision in the shape of a flattened W. The ends of the outer arms of the W come below and beyond the commissures of the lids, while the central point of the W comes below the middle of the lid. The skin between the arms of the two V's which go to make up the W is undermined, and the points of these two flaps are then united just above the middle of the W. Two triangular gaps are thus formed which may be closed in part by sutures or may be grafted or left to granulate. The operation brings no new skin into the lower lid, and, owing to the cicatrices which must result from the gaps which are left, is one in which recurrence may be very likely to take place. Other operations are ordinarily to be preferred when the deformity is so extensive as not to be easily corrected by the operation of Wharton Jones.

METHOD OF JAEGER AND RICHET.—Jaeger and Richet have devised a complicated operation which has little to commend it. An incision is made parallel with and slightly below the border of the lid. The edges of this incision are undermined so that the border of the lid may be raised into position. A gap is thus formed along the line of the incision. Parallel with and a little below it a second incision is made. This bridge of skin between the two incisions is completely freed and raised to meet the edge of the lid. The gap is thus transferred to the location of the lower incision. This may be closed in part by sutures passed transversely, thus converting the secondary horizontal gap into a T. The central bridge may, if too long, as is often the case, be shortened by resection at the middle.

THE METHOD OF DIEFFENBACH.—This method is intended to close a triangular gap. The base of the triangle is parallel with the border of the lid and slightly removed from it, the apex being away from the border of the lid. From each end of the base of the triangle lateral incisions are carried outward and away from the lids. The flaps thus marked out are undermined and slid inward to be united beneath the border of the lid. The excision of the cicatrix and the tension of the flaps are intended to be sufficient to correct the ectropion, but it must be remembered that no new skin is brought in from beyond the lid itself.

Other operations intended to correct ectropion depend for their success upon increasing the tension from side to side in the skin or through the whole thickness of the lid. They are applicable chiefly to those cases in which the ectropion is due to relaxation of the tissues, but an understanding of the principles upon which they are based may often aid the surgeon in closing a defect.

The simplest procedure of all is the excision, from the edge of the lid, of a V-shaped piece including its whole thickness. A hare-lip pin may be of use in uniting the edges. When the excision is at the middle of the lid the collection of tears may interfere with prompt union. The modification of von Ammon,* who makes the excision at the outer end of the lid, is preferable.

* Zeitschrift für Augenheilkunde, Bd. i., S. 529.

THE OPERATION OF DIEFFENBACH gives results similar to that of von Ammon. A triangular piece of skin is excised directly outside the outer canthus. The base of the triangle is horizontal and is directly continuous with the outer commissure. The apex points downward. The edge of the lid is then cut away for the distance desired, and a V-shaped piece of mucous membrane is also excised. The canthus is divided, and the skin of the outer part of the lid is then drawn outward to fill the gap originally made outside the commissure.

THE OPERATION OF SZYMANOWSKI is very similar to that just described. The ciliary border of the lower lid is excised for a distance of about 5 or 6 mm. (¼ in.) from the outer canthus. A very long and thin triangular flap of skin is then excised from just outside the outer canthus. The upper angle of this denuded area should be about 7 or 8 mm. (⅜ in.) above the outer canthus, and the lower angle nearly the same distance below it. (Fig. 449.) The outer end of the lower lid is then split for a short distance inward. The corner of the flap thus formed is drawn obliquely upward into the upper angle of the gap which has been formed to receive it.

THE OPERATION OF VON GRAEFE.—von Graefe has planned an ingenious and somewhat similar operation. He carries an incision from the inner to the outer canthus along the free border of the lid. From either end of this line a perpendicular incision is made, and the skin between these two incisions is freed to form a flap. From either or both corners of this flap a quadrangular piece of skin is cut away. The inner side of the quadrangle has a re-entrant angle. (Fig. 450.) In this manner, by drawing up the flap to fill the gap, the skin of the lid is drawn more tightly transversely; at the same time, perpendicularly it is less tense than before.

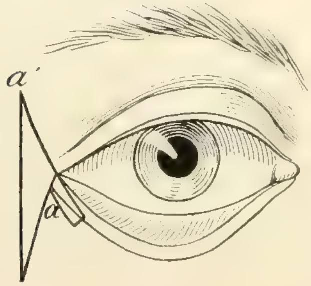

FIG. 449.

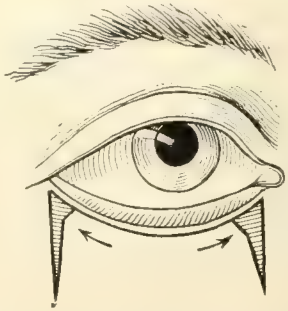

FIG. 450.

FIG. 449.—The Operation of Szymanowski. The outer end of the ciliary border is excised. The point *a* is brought up into the apex *a′* of the triangle excised outside the outer canthus.

FIG. 450.—Operation of von Graefe.

THE OPERATION OF RICHET is suitable for the correction of ectropion and is also available for filling a defect near the outer canthus. Two concentric incisions, convex to the outside, are carried around the outer canthus. The skin between the two is excised and the outer commissure is freed from the underlying bone. From the middle of the outer incision opposite the canthus an incision is carried downward and inward, with a long sweep, on to the cheek. From the middle of this cut another incision is carried upward and outward. The two pointed flaps between these incisions are then freed and transposed in such a manner that the apex of the outer flap is carried above the inner to fill the gap in the lower lid. (Fig. 451.)

In those cases in which the border of the lid and the conjunctival mucous membrane are both destroyed it is often necessary to resort to two operations—one intended to restore the skin surface, the other to replace the mucous membrane.

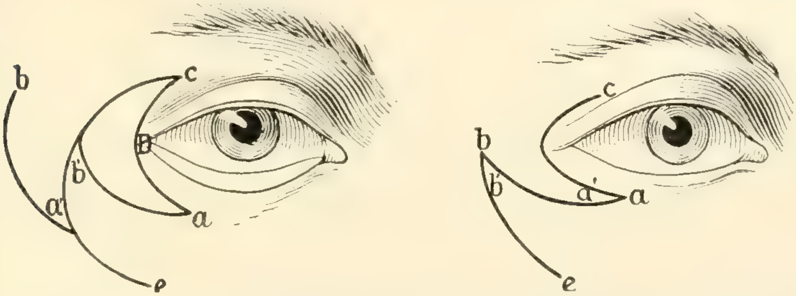

FIG. 451.—Operation of Richet. The gap between *a b'c* and *a d c* may be filled by the transfer of the two pointed flaps as the lettering indicates.

Various methods have been tried for the restoration of the mucous membrane. The flap which is used to form the external layer of skin may be doubled upon itself so as to make an inner as well as an outer layer. Grafts of mucous membrane have been taken with success from the vagina, the lip, and the inner surface of the cheek. Thiersch grafts also have been used to line the new lid. The conjunctiva of a rabbit has also been grafted upon the inner surface of the new lid. In any of these procedures the flaps which are to form the external surface of the lid may be prepared and their internal surfaces grafted before they are brought into their new positions, though if this is done the shrinkage of the flap is very great. Flaps of skin may be folded in so that the epidermal surface will be toward the eye. One of the most ingenious of the procedures of this sort is the folding down of a flap of skin from the upper lid to form the inner layer of the lower lid. The flap is left attached at the edge of the upper lid for some days until its nutrition is well established. Fuchs has taken a piece of skin, together with a thin layer of cartilage from the concha of the ear, to make the new inner lining of the eyelid.

These various procedures, however, in which the reconstruction of the whole thickness of the lid is involved are so intimately connected with the eye itself that, for the details of technique in operating and in the after-care, the article on the surgery of the eye must be consulted.

It is evident that in all operations involving the eyelids it is of the utmost importance to preserve, by the most careful dissection, every possible bit of sound mucous membrane.

Blepharoplasty.—While some of the operations thus far mentioned are adapted to the filling of defects in the lids, those which are to be described are intended primarily to fill deficiencies, although they are of course equally available as aids in correcting cicatricial ectropion.

The operations intended to restore the eyelid may be divided into various groups.

The first and by far the most generally useful method is the Indian—that of transplanting a flap of skin from the neighboring parts. In the early operations of this kind the flap was left with a broad pedicle, and in a few instances the pedicle was carried across an area of sound skin. The name of Fricke* is usually associated with the operation; but it has been variously modified, and adapted to different conditions, by Blasius, Hasner, Denonvilliers, Ammon and Langenbeck, St. John, and many others. (Fig. 452.)

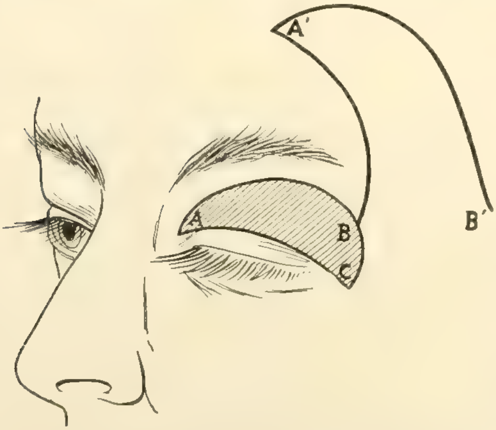

Fig. 452.—Operation of Fricke. In order to fill the gap *A B C* the flap *BA'B'* is cut from the temporal region. *A'* is brought to *A*. The secondary gap may be closed at once.

In most of the operations the flap is to be practically vertical when cut. It should have the form of the gap to be filled, but should be a third larger in size. The pedicle should be opposite to the inner or outer canthus and should immediately adjoin the gap to be filled. The flap may be taken, according to circumstances, from the skin at the inner or at the outer side of the eye, and may be either above or below the eye. The subcutaneous tissue should be included in the flap. When much cicatricial tissue exists about the face, the spot from which the flap is taken may be modified according to the conditions existing. The temple, the forehead, the region of the cheek bone, the side of the nose, have all been utilized for flaps. The smaller the pedicle the more easily the flap may be turned into its new position. Langenbeck especially has called attention to this fact and also to the increased ease of turning the flap by curving away from the eye the end of the incision next the pedicle. The flap in all cases should be wide enough to overcorrect slightly the deformity, because there is always some tendency to contraction of the flap.

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* Fricke: "Bildung neuer Augenlider nach Zerstörung und dadurch hervorgebrachter Auswärtswendung derselben," Hamburg, 1829.

The pedicle should be placed in such a manner that if it contracts it will not tend to draw the lid away from the eye. Thus, it should be somewhat toward the canthus rather than directly opposite the gap in the lid. The flap should be sutured into position with the greatest accuracy, but it is always wise first to close the area from which the flap has been taken. Otherwise suture of the denuded area may pull upon the pedicle enough to draw the lid out of position.

While the conditions in no two cases are exactly alike, and while in practice the condition of the skin about the eye is the factor which determines the planning of the flaps, nevertheless a clear understanding of certain well-recognized types of flap is essential.

HASNER'S OPERATION.—Hasner* has, in a similar manner, taken a flap from the glabella and forehead to fill a gap in the inner part of the lower lid. (Fig. 453.) Hasner has also applied the same principle to cases in which the upper and the lower lid about the inner or outer canthus had both been destroyed, with the loss of a horseshoe-shaped area. In this operation the end of the flap farthest from the pedicle is divided, so that when it is transferred to its new position one arm will fit into the upper lid, while the other will fit into the lower lid. (Fig. 454.)

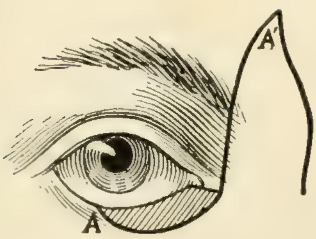

FIG. 453.

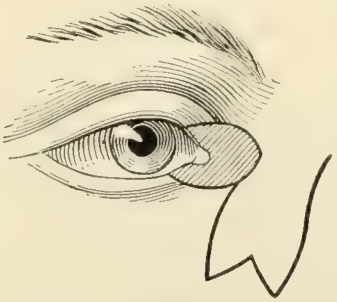

FIG. 454.

FIG. 453.—Hasner's Operation. The tip of the flap *A′* is brought to the end of the defect *A*.

FIG. 454.—Hasner's Modified Operation. A forked flap for reconstruction of the canthus may be taken from the nose or from the temporal region.

OPERATION OF BLASIUS.—The operation of Blasius closely resembles that of Hasner, except that the flap is taken from the skin covering the side of the base of the nose when the gap to be filled is near the inner commissure.†

St. John, instead of taking a vertical flap from one side of the eye, took his flap for the upper lid from just below the lower lid, in such a manner that the scar would follow the wrinkle in the skin at the edge of the orbit.‡

Schaler and Hirschfeld have transferred flaps of skin from one eyelid to the other in order to close small gaps.

* Medicinische Zeitung, March, 1842.

† "Entwurf einer anatomischen Begründung der Augenheilkunde."

‡ Trans. Am. Ophth. Soc., 1893, p. 597.

Operation of Landolt.—Landolt (*Arch. d'Ophthalmol.*, 1885, p. 492) has devised a most ingenious operation for the restoration of the lower lid by means of the skin from the upper. When a strip along the whole length of the lower lid is destroyed two cuts are made along the whole length of the upper lid. One is just above and parallel with the lid border. The second is not quite 1 cm. ($\frac{2}{5}$ in.) above the first. The ends of the flap thus marked out are left attached. The entire bridge of skin is then separated, together with the orbicularis muscle, and is displaced downward, to form the new lower lid. (Fig. 455.) The gap in the upper lid is closed by sutures at once. At a later operation the pedicles of the flap are cut across, and the ends may then be sutured into accurate position at either canthus. The operation is unsuitable in those cases in which the defect extends far from the lid border.

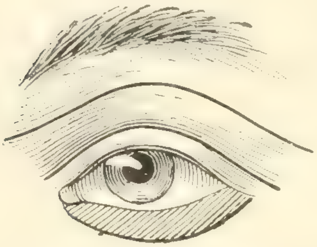

Fig. 455.—Operation of Landolt. A flap attached only at the two ends is lowered from the upper to fill a gap in the lower lid. The attached ends are divided only after the flap has become firmly adherent in its new situation.

Operation of Monks.—Monks (*Boston Medical and Surgical Journal*, Oct. 20th, 1898) has introduced an entirely new principle in plastic surgery, suggested to him by a procedure of Dunham.

Monks filled a defect in the lower lid by a flap taken from the forehead. The peculiarity of his procedure consisted in making the pedicle include only the anterior branch of the temporal artery and vein, with the surrounding subcutaneous tissues. The flap was brought into position by tunnelling under the skin between the proximal end of the pedicle and the gap to be filled. Thus the pedicle was buried without making an external scar. The incision made in dissecting out the pedicle and the secondary gap in the forehead were closed by sutures.

The second method of blepharoplasty is the French, which includes operations of an entirely different character. A flap taken from adjacent tissue is slid directly into the gap without jumping it across an intervening area of undisturbed skin. Under most circumstances these operations are less satisfactory than those in which a flap with a pedicle is turned into the gap. But in certain instances the skin of the parts immediately adjacent is the best.

Method of Dieffenbach.—The method of Dieffenbach* is adapted for closing a triangular gap in the skin of the middle of the lower lid. A horizontal incision is carried outward from the angle of the defect close by the outer commissure. This is continued far enough to obtain a flap sufficiently wide to fill the gap. The incision is then carried downward parallel with the outer side of the defect. (Fig. 456.) The trapezoid flap of skin thus freed is slid inward to fill the gap in the lid. Whatever portion of the gap left in the cheek cannot be closed satisfactorily by sutures should be covered by Thiersch grafts.

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*Caspar's Wochenschrift, Bd. i., S. 8.

Szymanowski* modifies the incision in a manner which gives a slightly wider flap and at the same time renders it easier to fill in the area from which the flap is taken. He carries the incision upward and outward instead of directly outward. The contraction of scars made by this incision would have less tendency to draw the new lid out of place.

Arlt † makes the free upper edge of the flap wider than the pedicle. He finds that, by carrying the lower end of the outer incision farther down upon the cheek, the flap may be turned more readily.

The chief objection to these operations is that a scar is left on a conspicuous portion of the face over the upper part of the malar bone. In order to obviate this, von Siklossy has proposed carrying the original horizontal incision directly backward, if need be, to the ear. By undermining the skin below this incision it is indeed possible to form a very wide flap, which can then, after the gap has been closed, be slid diagonally inward without any further cuts. If, however, the tension is not sufficiently removed by this long incision, it may be carried downward just in front of the ear. Thus, any new gap created may be concealed by the hair, but at the expense of a long scar. (Fig. 457.)

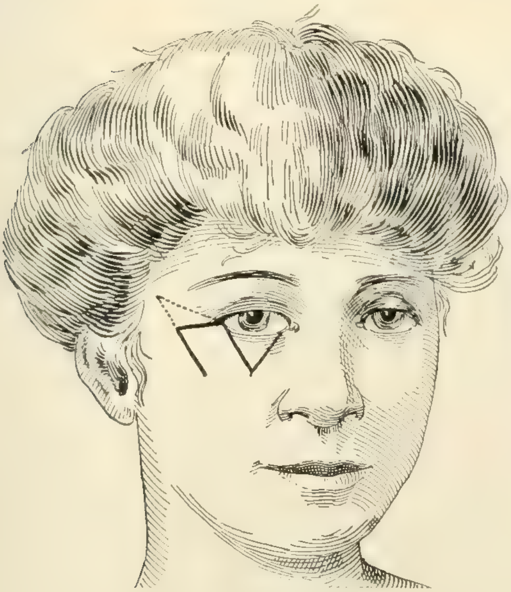

Fig. 456.

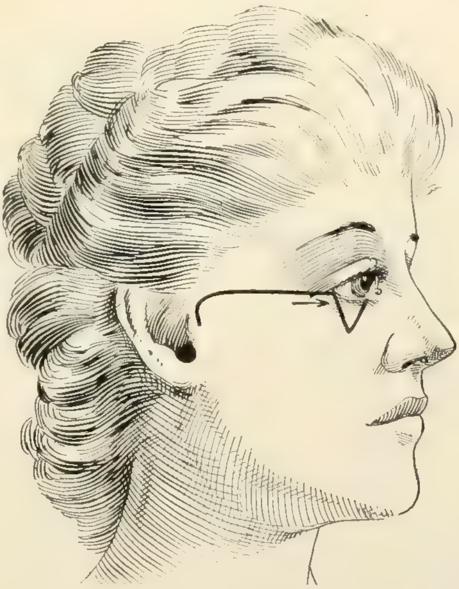

Fig. 457.

Fig. 456.—Operative Method of Dieffenbach. The dotted line shows how Szymanowski modifies the incision.

Fig. 457.—Operation of von Siklossy. The secondary gap is transferred to a point near the ear.

Harlan's Method of Closing the Secondary Gap.—Harlan ‡ has turned down a flap from the temple to help close the secondary gap created by the sliding in of the flap in Dieffenbach's method. The advantages of this second flap are that it brings sound skin alongside the primary flap and transfers the granulating area to a point above the canthus. (Fig. 458.)

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* "Handbuch der oper. Chir.," S. 223.

† Graefe u. Saemisch, Bd. iii., S. 475.

‡ "System of Diseases of the Eye," by Norris and Oliver, viii., p. 118, Figs. 40, 41, and 42.

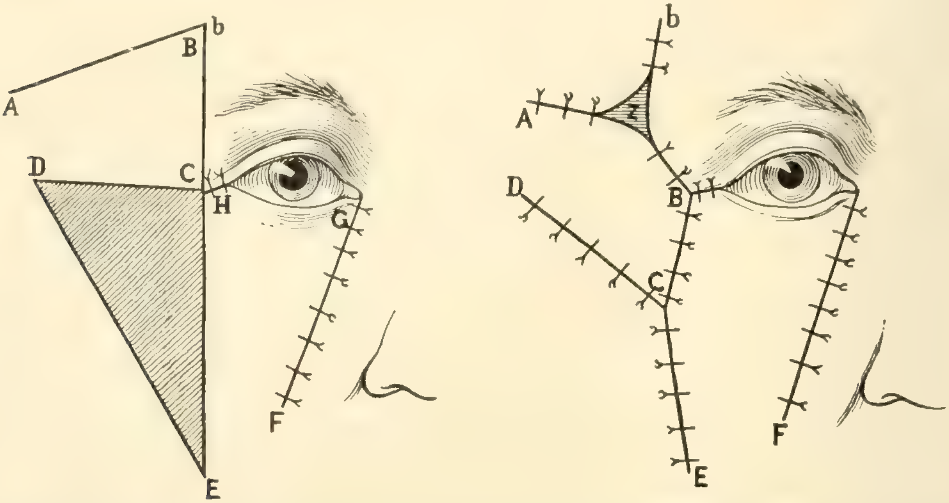

Fig. 458.—Harlan's Method of Closing the Secondary Gap, in Dieffenbach's Method. The secondary gap *DCE*, made by sliding in the flap *EHGF*, is closed by Harlan by means of a flap, *ABCD*, which is taken from the temporal region and which can be turned down on its pedicle, leaving only a small tertiary gap at Z.

In order to fill a gap in the inner part of the upper lid, Landolt split the sound external portion of the lid into a flap of mucous membrane and a flap of skin. The cutaneous flap is freed from the edge of the lid upward as far as the eyebrow. Thus a flap is freed which may be slid inward to close the gap. The operation is not to be recommended. Instead of bringing tissue from other parts to supply the defect it mars the remaining sound portion of the lid.

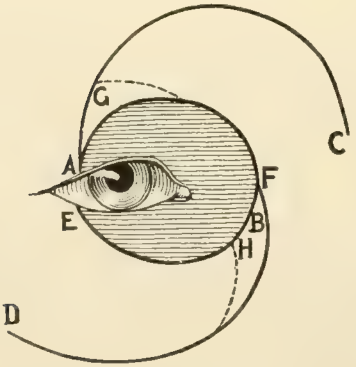

Fig. 459.—Hasner's Second Operation. Hasner's method of filling a gap at the inner canthus allows greater mobility of the borders of the defect. The flaps *CAF* and *EBD* may be slid into the defect. If the tips of the flaps are redundant they may be trimmed off, as shown in the dotted lines to *H* and *G*. Cutting off the point of the upper flap to *G* gives a straighter new border to the lid. (See Norris and Oliver: "A System of Diseases of the Eye," p. 119.)

Harlan has modified this procedure somewhat by dividing the flap of mucous membrane from the skin flap more extensively. He freed the cutaneous flap to a point beyond the outer canthus and upward to a point above the eyebrow. In this manner much greater mobility of the flap was obtained, and any secondary gap that might remain was transferred to a point well outside the canthus.

Second Operation of Hasner.—When the defect is at the corner of the eye and involves both lids, the method of Hasner is useful.

Two sickle-shaped flaps are formed immediately adjoining the gap. The upper incision has its base at the bridge of the nose and its tip above the eye, while the conditions are reversed with the lower flap. By bringing the tip of the lower flap up against the base of the upper, the gap is filled. Hasner has modified the operation slightly by shortening the tips of the flaps.* (Fig. 454.)

THE OPERATION OF BUROW.—The operation of Burow involves the removal of a triangular piece of skin from the temporal region. The apex of the triangle is to be upward, the base at the level of and just outside the outer commissure. The area of skin excised should equal the size of the gap in the lower lid to be filled. The skin below the freshly excised area is then undermined and slid inward. (Fig. 460.)

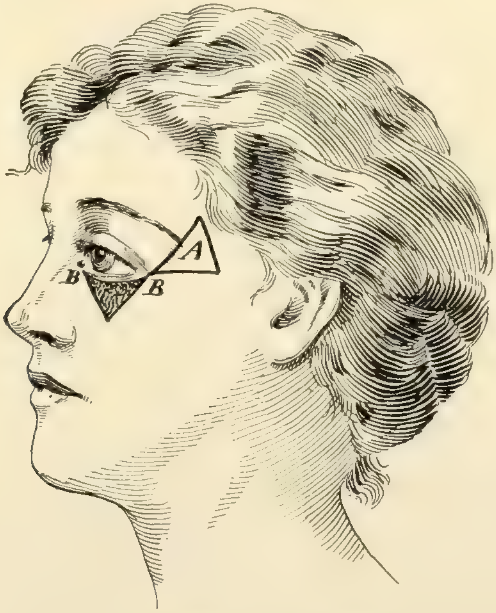

FIG. 460.—Operation of Burow. In order that the point *B* may be brought readily in contact with *B'* (immediately below the inner canthus), Burow excises the redundant skin in the triangle *A*.

The operation might be useful when two areas of the lids were lost, but the removal of the second triangular area, in order to allow better adjustment of the flap to fill the original area, involves an unnecessary sacrifice of sound skin.

THE OPERATION OF KNAPP.—In cases in which the gap in the lower lid is quadrangular in shape Knapp carries two parallel horizontal incisions out over the cheek from the upper and lower sides of the defect. The flaps of skin between the incisions are undermined and they are made long enough to be drawn inward to fill the gap. The objection to the operation is that the lateral stretching of the flap causes a loss in its height and may consequently make the amount of skin intended for filling the gap somewhat deficient. (Fig. 461.)

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* Hasner: "Entwurf einer anatomischen Begründung der Augenheilkunde."

The Italian Method.—Under most unusual circumstances it may be necessary to resort to still a third method—the Italian. Paul Berger (Congrès français de Chirurgie, October 9th, 1899, p. 361) has described the technique. The patient must first be made gradually accustomed to the position which later he or she will have to occupy for two weeks. The arm is so placed that its inner side comes close to the outer canthus. The flap is first carefully marked off on the arm and is then freed and sutured in position. The pedicle is left rather broad and may be cut across at the end of two weeks. The agony endured from the constrained position is so great that the method has been used but seldom. Although the upper arm has generally been used for the flap, the constraint is much more endurable when the forearm is used.

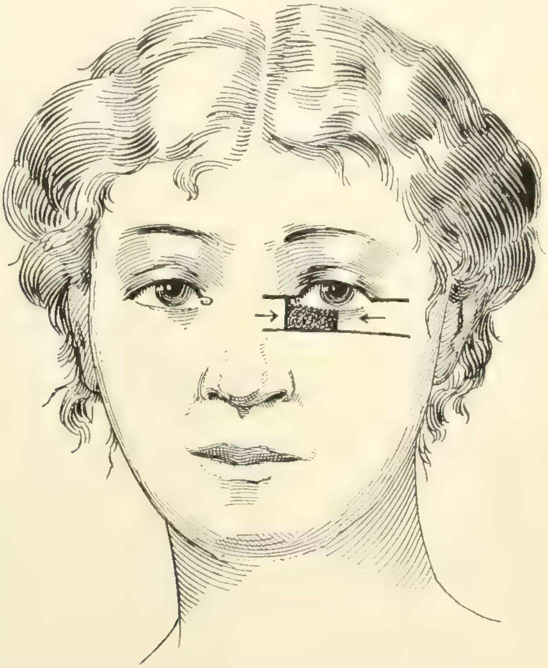

FIG. 461.—Operation of Knapp. A rectangular flap is dissected up on each side of the defect, and the two are then united so as to obliterate the gap.

The Indian method is in most instances so very satisfactory and gives rise to so slight a scar that practically the only cases in which the Italian method need be considered are those in which all the skin about the upper face has been involved in scar tissue.

The use of Wolfe grafts in plastic work upon the eyelids is mentioned in the section on Skin Grafting (p. 622).

While, so long as the dressing is in place, there is usually no risk of the displacement of the flaps due to opening the lids, it is nevertheless a wise precaution, in certain instances, to unite the upper and lower lid margins with two or three temporary silk stitches.

PLASTIC SURGERY OF THE NOSE.

In this section the classical work of Nélaton and Ombrédanne—"La Rhinoplastie," 1904—has been used with the greatest freedom. Many of the illustrations are taken from their work. The smaller treatise of Depage—"La Chirurgie Réparatrice de la Face," 1905—has also been freely consulted in this and the preceding sections.

Loss of the nose has in the past been due to many causes. In India, for example, amputation of the nose was a common form of punishment. In Italy the noses of brigands were cut off. Among the Egyptians, Greeks, and Romans this mutilation was a form of punishment for adultery; in the twelfth century it was a penalty for assault upon women. In all these instances the intention was to stamp the victims as criminals and to make them permanently repulsive. When the Danes invaded England, women and young girls cut off their noses in order to save their honor by making themselves hideous. In Germany the duels between students have at times been responsible for nasal disfigurement. In some instances in personal fights parts of the nose have been bitten or cut off. Fortunately, with the advance of civilization the loss of the nose from these causes is less frequent.

The loss of the nose has occurred as the result of gangrene during typhoid fever and severe confluent smallpox. Anthrax and the Aleppo boil have destroyed more or less of the nose. Gangrene of the nose may also follow severe frost-bite. The chief causes of destruction are, however, syphilis, tuberculosis, and malignant disease. Fortunately, the treatment of the last two diseases by means of the x-ray has diminished the liability of extensive destruction. The recognition of the necessity for prompt and efficient treatment has decreased the ravages of congenital syphilis. Syphilis is most likely to produce destruction of the bony supports of the nose. Tuberculosis and malignant disease commonly destroy portions of the external surface.

In order that the hideous disfigurement due to the loss of the nose might be removed, rhinoplasty has been practised for centuries. It is one of the oldest branches of surgery and, from the three different procedures practised in the different countries, the general methods have been called the Indian, the French, and the Italian.

As in any branch of therapeutics the multiplicity of remedies indicates the ineffectiveness of all agents, so the great number of rhinoplastic operations which have been devised indicates that none is satisfactory. In fact, no operation in plastic surgery offers such difficulties.

The distinguishing characteristics of the three leading methods may be briefly stated as follows:—The Indian method consists in taking a flap from the forehead and bringing it into place by twisting the pedicle. The French method is constituted by sliding flaps inward from adjacent parts. The Italian method is characterized by the practice of taking a flap from the arm and suturing it into position without completely severing its original attachments until after it has united sufficiently to be nourished by its new attachments.

Innumerable modifications of the original operations have been devised, chief among them being the doubling over of a flap, the use of an internal and an external flap, and the use of flaps which include periosteum, bone, or cartilage.

The selection of the method of operation must depend upon the degree of destruction of the nose, upon the soundness of the skin of the surrounding parts, upon the general health and age of the patient, and upon the necessity or desirability of minimizing the scars made upon the face. In general, it may be stated that when the bony or cartilaginous supports of the nose are destroyed, any operation which brings into position only an unsupported flap of skin will inevitably give an unsatisfactory result as soon as the inflammatory swelling which follows the operation subsides. Double flaps which employ an internal and an external layer of skin yield slightly better, but still unsatisfactory, results. Some form of bony or cartilaginous support is essential if the contour of the new nose is to be maintained. Nature tends to flatten out all projecting areas of skin and subcutaneous tissue. This fact, which helps to simplify most plastic work, is a direct disadvantage in operations like rhinoplasty, where the attempt is made to create projections.

The Indian Method.—The original Indian operation is one that has little to commend it, although the immediate results may seem satisfactory. The inflammatory swelling gives considerable stiffness to the nose at first, but later cicatricial contraction occurs, the nares become very small if not completely obliterated, and the skin loses its shape and sinks into a shapeless mass. In these cases the criticism is true that rhinoplasty has converted a repugnant into a ridiculous deformity.

The many operations performed and the attempts to perfect the technique have, however, been of service in determining the most useful incisions and the best methods of treating the pedicle, and in establishing similar general rules. They laid the foundations for future work. A thorough understanding of the technique is therefore essential.

A pattern of felt is first to be made of the proper size to fill the defect. Then, with an allowance for shrinkage of about a third, the shape of the flap is marked out on the forehead. The free end which is to form the tip of the nose and the septum lies at the edge of the hair. The pedicle, which should be about 2 cm. ($\frac{4}{5}$ in.) wide and of about the same length, lies between the inner ends of the eyebrows. Thus the arteries on each side of the nose are included in the pedicle. The flap is turned through one hundred and eighty degrees to bring it into position. (Fig. 462.)

Many variations from the original method have been devised. Some operators change the form of the pedicle, others the shape of the flap, and others still the direction of the flap.

It is plain that, as just described, the pedicle is turned in such a manner that its cutaneous surface crosses over, at the base of the nose, a small area which has not been denuded of skin. Under these conditions the pedicle must be cut across as soon as the nutrition of the flap is assured. This cut may be made at the level of the upper edge of the gap to be filled. In that case any portion of the pedicle that is separated from the flap may be replaced in its original position. If desired, the pedicle may be severed as near its base as is possible. It may then be unfolded and be placed over the glabella. By carrying one incision at the side of the pedicle downward underneath the other, the turning of the flap is greatly facilitated, but the nutrition of the flap may be impaired. First one and then the other artery entering the pedicle is cut off if the incision is carried far enough. But by giving the pedicle a slight obliquity, not only is it subjected to less torsion, but the flap need not be so long, because the pedicle can be used to fill a portion of the gap in the nose.

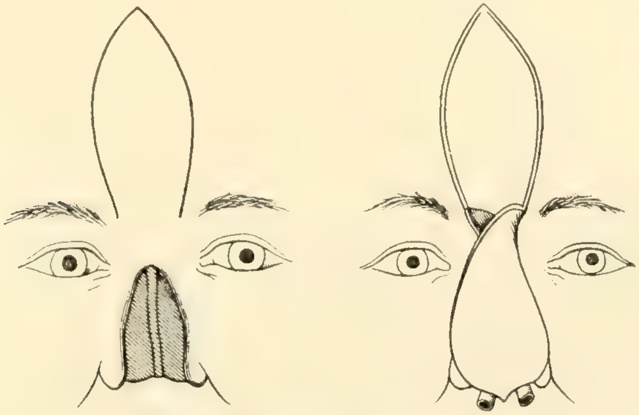
FIG. 462.—The Indian Operation.

The various methods in which the incisions may be prolonged downward upon the nose are best understood from the diagrams. (Fig. 463.) Lisfranc and Labat have carried the incision on one side down to or even across the base of the nose. Dieffenbach prolonged one incision down to the upper edge of the defect. From this point a cut may be carried down on each side of the defect. The skin included between these cuts may be inverted, or the area of skin included between them and about the edge of the gap may be excised. In all of the modifications except that of Landreau the pedicle lies between the eyebrows. Landreau changes the position of the whole flap by making the pedicle come from the middle of the forehead, so that when it is swung into position there is much less twisting of the pedicle.

The great risk in this last method is that the nutrition of the flap may be impaired. The natural course of the vessels is disregarded. Furthermore, a greater gap and one harder to close is made in the forehead. In the other operations at least one of the arteries which run up, one on either side of the nose, is preserved. If either artery is cut, the risk of sloughing is greater than if both are left as in the original method.

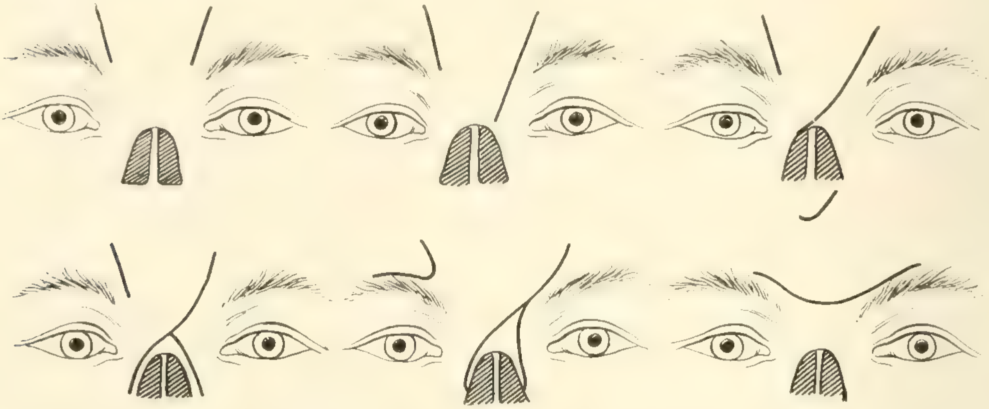

FIG. 463.—Diagrams Showing the Different Ways of Making the Pedicle of the Flap from the Forehead. (After Nélaton and Ombrédanne.)

After the flaps have united in their new positions and when the dressings are removed, the pedicle is always found projecting outward as a brawny mass of skin. In time, as the swelling goes down, this deformity becomes less conspicuous. In those operations in which the pedicle is applied directly to a freshly denuded surface, in approximately the position it will always occupy, no special thought need be given to this matter. Any necessary retouching may be done later.

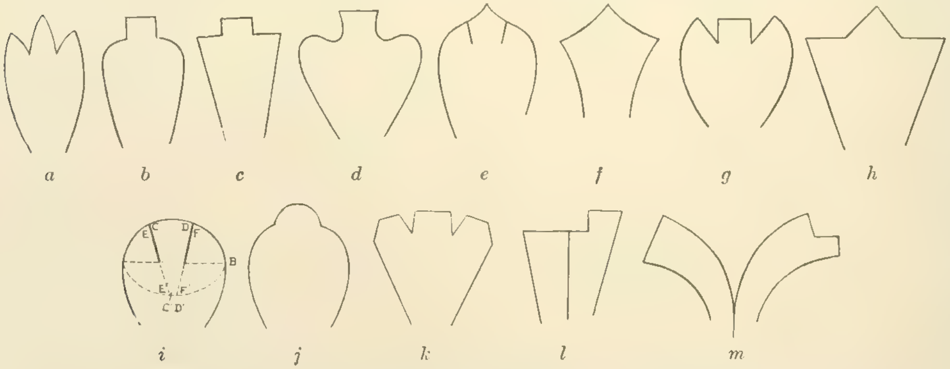

FIG. 464.—Diagrams Showing Some of the Various Forms of Frontal Flaps which have been used in rhinoplasty.

The modifications in the shape of the flap have been made chiefly at the free end which goes to form the septum, the tip of the nose, the alæ, and the nostrils. In the original operation the flap was oval. In order to facilitate moulding the flap into its proper shape, Delpech divides the upper portion of the flap into three points (Fig. 464, *a*), while Langenbeck divides his into two points with a square piece between them (Fig. 464, *g*); von Graefe makes a heart-shaped flap with a square piece above to form the septum (Fig. 464, *d*); Lisfranc's main flap has a triangular shape with a small square above it to form the septum (Fig. 464, *c*); a second one of Langenbeck's flaps also has a triangular shape, but with a smaller triangle above it (Fig. 464, *h*). Labat gives to the flap the shape of the ace of spades. (Fig. 464, *b*.) There are various other modifications in the shape of the flaps: the central portion may be triangular: the other angles may be sharp or rounded; the divisions between the upper portions of the flap may be wide or merely incisions, etc. Linhart and Blasius have divided the operation into two stages. At the first stage they fold over those portions of the flap which form the alæ, and double in the part which forms the columna; at the second operation they turn down the whole into position. The procedure offers no special advantages. (Fig. 464, *i*.)

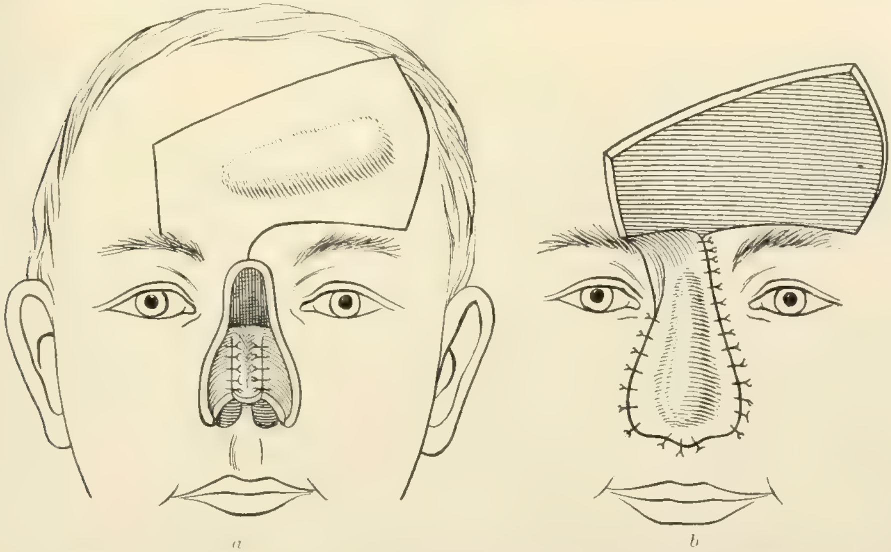

Fig. 465.—Operation of Nélaton and Ombrédanne. ("La Rhinoplastie," 1904.) At a preliminary operation a piece of the eighth costal cartilage, which ultimately is to form a bridge for the nose, is inserted transversely beneath the skin of the forehead through a short cut on the side at the edge of the hair. Six weeks later the flaps may be folded and turned into position. In *a* the three internal flaps are shown; in *b* the frontal flap, moulded at the tip, is shown turned down into place.

The method which is characterized by taking a longer flap and folding over the entire tip to form an internal surface, has no special advantages. Nothing is to be gained, either, except in special cases, by taking two smaller rather than one large flap from the forehead. (Fig. 464, *l* and *m*.)

Innumerable methods, which it is not necessary to describe in detail, have been devised for utilizing double flaps: one to be folded in to form an inner surface for the new nose, while the other is turned or drawn into position to cover the first. The method of Koenig may be mentioned because he took both flaps from the forehead. The internal one he cut as a long narrow strip from the median line and folded it down into position, while he turned down the external flap from the side of the forehead.

Nélaton and Ombrédanne,* in what they recommend as the method of choice, form an inner surface of the new nose by folding in three flaps; one folded down from the glabella, and one on each side folded inward. These they cover with a flap cut from across the forehead, beneath which flap a piece of the eighth costal cartilage has been previously inserted. The operation is in all essential respects the same as that which they recommend for the correction of saddle nose. The direction of the flap is changed in order to gain length sufficient to allow some infolding of the lower end, which is to serve as a lining for the new nostrils. (Fig. 465.)

At best, the Indian operations produce terrible scars upon the forehead. In most cases the larger exposed areas which are left may best be covered by Thiersch grafts. Attempts have been made, however, to minimize the size of the gap by lateral incisions extending outward from the upper border of the defect along the border of the hair. Thus, two lateral flaps are formed which may be approximated. (Fig. 466.)

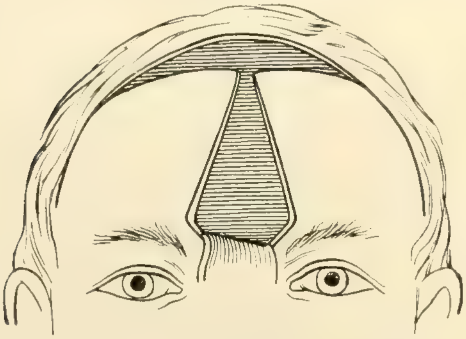

FIG. 466.—Method of Approximating Edges of Gap Left after Turning Down a Flap from the Forehead.

The French Method.—In attempting to build up an entirely new nose the method of using flaps drawn in from the cheeks is absolutely useless. The method of folding or turning in flaps in cases in which the loss is partial yields excellent results. In those operations which have been done to construct an entire nose in this manner, attempts have been made to secure the flaps in their new position in one of two ways:—either the outer border of the flap may be secured to the superior maxillary bone or periosteum at the side of the nose, or else the flap may be jumped across undisturbed skin and underlying tissues at the side of the nose. But even under these conditions flaps of skin not held forward by firm support must sink into a shapeless mass. Nevertheless, Serre, Nélaton, Hueter, and Syme have described operations by which flaps taken from the cheeks just outside nasal defects have been slid inward to make a new nose. In all of these instances the pedicles of the flaps have been above, at the base of the nose. The flaps have been united in each case in the median line. In operations of this nature, however, in which both external and internal flaps are used, the French method may be of greatest value.

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* "La Rhinoplastie," p. 188.

The procedure of Blasius may be mentioned here, as in it flaps are taken from the cheek, which, instead of being turned or slid into their new position, are folded in so that the raw surfaces are exposed. Then the skin becomes the lining for the new nose, the outer covering of which must be provided for in other ways. The operation, however, is not to be recommended when there is any extensive loss of bony support.

Many operations have been performed in which one set of flaps was taken from the cheek and the other from the forehead. One of the earliest was that of Verneuil, who folded down a frontal flap to form the inner surface of the nose, and who then slid forward, outside of this, flaps from each side of the cheek, which were stitched together in the median line. A nose so formed, however, must necessarily be shapeless and unsatisfactory.

Much more rational is the method of Thiersch, who folded in a flap from each cheek toward the median line. Thus the inner surface of the nose was formed. A flap was then turned down from the forehead to cover the outside of these flaps. By making the first flaps long enough, the outer ends may be folded backward in the median line, raw surface to raw surface, to form a new septum. The cutaneous surface of these flaps would thus line the entire anterior and inner walls of the nasal cavity as far back as the septum was destroyed.

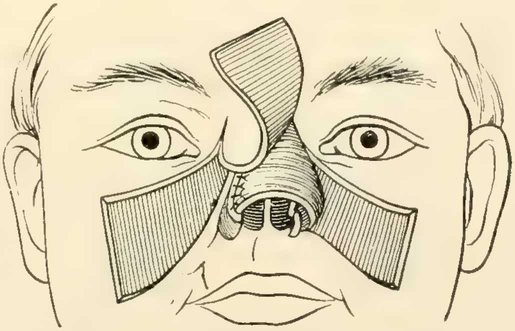

Fig. 467.—Operation of Helferich. A flap from one cheek is folded in to form the inner layer. It is covered by a flap from the other cheek.

Helferich* has folded a flap in from one cheek, and has covered the outer raw surface with a flap turned in from the opposite cheek. (Fig. 467.) The pedicle of the first flap was at the side of the nose. That of the second was above, between the eye and base of the nose. In this operation no provision is made for a septum. The external flap cannot be made to cover accurately and completely the raw surface of the internal flap. In case any rudimentary ala remains on the side from which the internal flap is taken, the flap at first must of necessity be folded around outside of it. At a secondary operation the pedicle of this flap may be cut across and the free edge pushed forward to be sutured to the remnants of the ala, the nose thus gaining in symmetry and in size.

Keegan folded down two flaps from each side of the base of the nose, and covered their anterior raw surfaces with a frontal flap. The diagrams further on illustrate many of the various procedures.

The Italian Method.—The Italian operation is one which presents certain distinct advantages and in selected cases is the most satisfactory. A flap is transferred, in two or more stages, from some part of the arm or forearm. No scar is made upon the cheek or forehead. The method, however, is one which entails considerable suffering on the part of the patient, owing to the awkward and strained position in which the arm must be fastened for a fortnight. Furthermore the wound must, from its location, become more or less foul and offensive. There is also a certain amount of risk that an embolism may occur when the arm is set free. This is secondary to venous thrombosis, due to more or less infection and also in some measure to the interference with the circulation in the constrained arm. Although previously described, the operation is associated with the name of Tagliacozzi, in part on account of the apparatus which he devised for securing the arm to the head. This apparatus consisted of a canvas cap covering the whole of the top, back, and sides of the head. Holes were cut out for the ears. The cap extended down the neck where it was joined to a camisole which fitted snugly about the chest, but allowed free movement of the arms. Fastened to the camisole on the side on which the flap from the arm was to be taken was a cloth gutter which extended forward in such a way as to fit below the arm when it was raised and flexed so that the fingers might grasp the back of the head. From the vicinity of the bend of the elbow two cloth bands extended back on each side, one of each set being fastened to the side of the cap, the other to the camisole. A continuation of the gutter extended onward along the back of the forearm to the wrist, where it broadened out in such a manner as to fasten the wrist to the top of the head. Thus the arm was fixed so that its anterior surface lay close in front of the face and so that the spread fingers grasped the back of the head.

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* Gesellschaft f. Chir., 1888, Bd. xviii., S. 108.

Berger modified somewhat the position in which the arm was fixed, by raising it higher and rotating it in such a manner that the forearm lay obliquely across the front of the head. The upper arm lay a little to one side of the middle of the face and the head was turned a little toward it to bring the nose into position. There was no essential difference between the two methods as regards the manner of attaching the flap.

With the introduction of plaster of Paris the various forms of specially constructed apparatus have been practically supplanted. The plaster bandage should encircle the chest below the arms, extend upward at the back and sides of the neck, and cover the entire scalp and forehead. The ears need not be included, nor need the plaster extend over the shoulders in front. Greater strength may be gained by incorporating within the bandage a metal strip, curved so as to extend in the median line from the forehead backward across the top of the head and downward along the neck and back to the bottom of the plaster. The padding should be of such a nature that it does not slip out of place or become matted. Relatively thin felt, pieces of Canton flannel, and glazed sheet wadding are the best materials. If the plaster bandages are laid on smoothly, an ordinary knit undervest without seams or buttons makes a most satisfactory padding for the chest, provided it be properly reënforced by extra padding in those places only in which pressure is likely to do harm. The head may be covered with Canton flannel. Padding may be needed about the occiput and mastoid processes and to a less extent on the parietal and frontal prominences. The head should be flexed and turned a little toward the side from which the flap is to be taken. The part of the plaster cast which includes the head, neck, and chest, may be made removable by splitting it across the front of the chest and holding it in place with straps. It should be applied at the latest on the day before the operation, in order that it may be thoroughly hard. It may well be worn at times during several days in order that the patient may become accustomed to it. When the flap is in position, and with the patient fully anæsthetized, the arm is fixed by strips of plaster bandage applied across the back of the arm and forearm. Each strip should extend from the hand, which is fixed to the head, along the forearm and arm to the back of the chest. The fingers may be left free. Strips of plaster bandage must also be applied at the outer side of the flexed arm to prevent motion of the elbow from side to side. Particular pains should be taken to avoid pressure on the tip of the elbow.

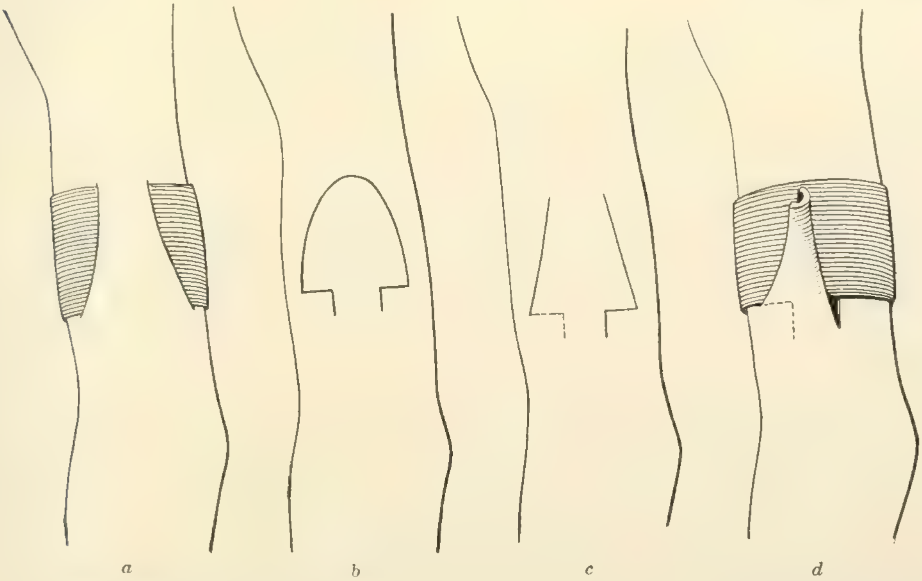

Fig. 468.—Methods of Flap Formation by Utilization of the Arm. (After Nélaton and Ombrédanne.) *a*, Flap of Tagliacozzi. Both ends are at first left attached, and a strip of gauze is passed beneath. Later, one end is cut free and fastened to the nose; *b*, flap of von Graefe; *c* and *d*, flap of Dieffenbach. At the first step both ends are left attached and the flap is folded on itself. At a later stage one end is cut free and fastened to the nose.

Depage has had satisfactory results from using ordinary bandages without special apparatus of any sort.

In the original Italian operation a flap was taken from the anterior surface of the upper arm over the belly of the biceps. The broad pedicle of the flap lay about an inch and a half above the bend of the elbow. The narrower upper end, which was sutured to the root of the nose, lay well up on the arm. The broad pedicle when cut across was moulded into shape to form the septum and the two alæ, together with a lining for the nostrils. This may be facilitated by splitting the broad end into three parts. In all the modifications of this method the pedicle is used to form the lower part of the nose. (Fig. 468.)

Von Graefe and Dieffenbach have modified somewhat the shape of the flap. They made a longer and narrower pedicle resembling the handle of a shovel. This longer, narrower pedicle obviously impairs the nutrition, but allows greater freedom in moving the flap and may be very useful in cases in which the alæ are not destroyed, but in which the lower septum is lacking. Dieffenbach freed only one side of a long pedicle at first, thus insuring better nutrition of the flap while at the same time gaining something in mobility.

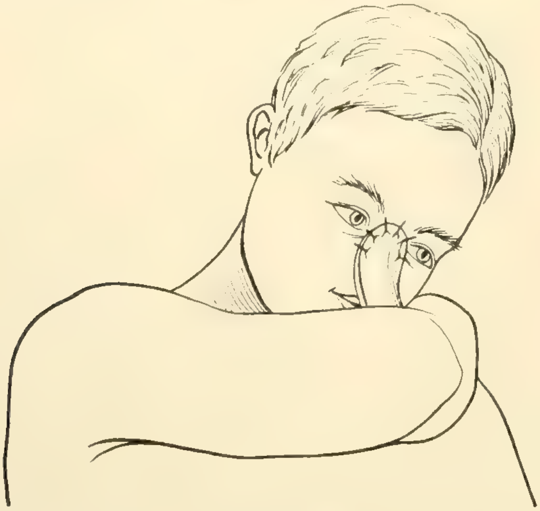

Fig. 469.—The Operation of Fabrizi. The flap is taken from the arm close to the bend of the elbow.

The Operation of Fabrizi.—Fabrizi * has taken a flap from the anterior and outer lower part of the upper arm. (Fig. 469.) He fixed the arm with the elbow in front of the chin and with the hand placed on the opposite shoulder; the head, as a matter of course, was flexed in order to bring the nose near the elbow.

The Operation of Steinthal.—Steinthal † has devised an operation which involves a double transfer of a flap from the front of the chest. The flap is first attached to the radial side of the forearm just above the wrist. (Fig. 470, *a*.) The second step is taken when the union between the flap and the forearm is sufficient to insure the nutrition of the flap. It includes the separation of the flap

* Gazette des Hôpitaux, 1841, p. 429. † Beiträge zur klin. Chirurgie, 1901, xxix., S. 485.

and the immediate suture of the free end to the base of the nose. The hand is fastened to the head, with the palm on the forehead. (Fig. 470, *b*.)

METHODS OF ISRAEL AND OF KUESTER.—Israel * and Kuester † have utilized a flap from the upper arm with the cutaneous surface turned inward. (Fig. 471.) The position in which the arm is attached is exactly as it is in the original Italian operation, but, by having the pedicle above instead of below, the position of the flap is exactly reversed. The raw surface must, of course, be covered later by an anterior flap taken from any desired point.

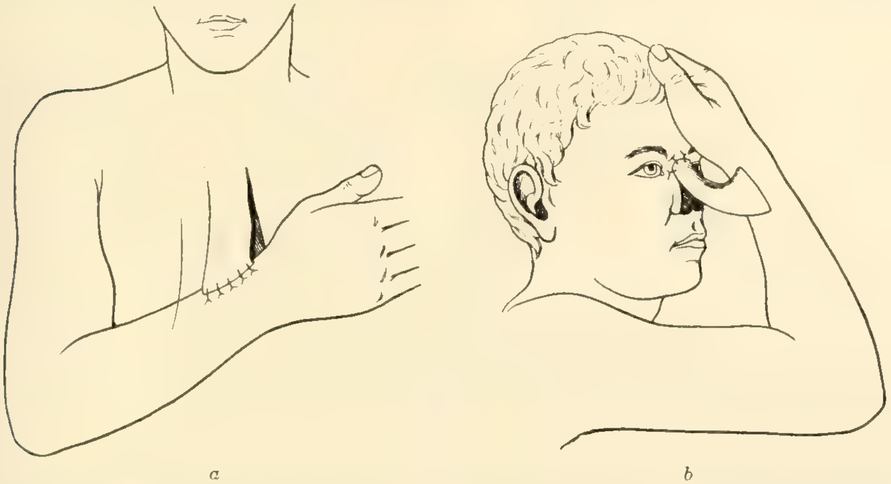
FIG. 470.—The Operation of Steinthal. *a*, First step: attachment of the flap from the chest to the radial side of the forearm preparatory to its transfer to the nose; *b*, second step: detachment of the chest flap from the arm and reattachment to the nose.

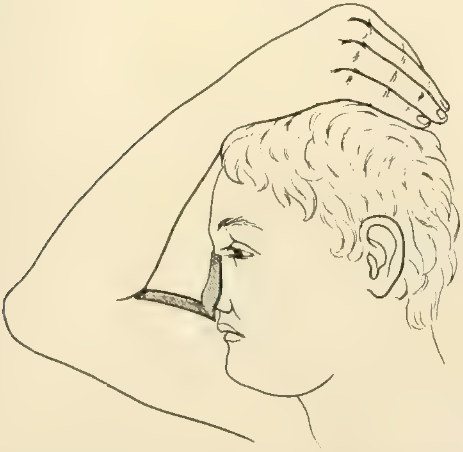
FIG. 471.—Kuester's Operation. A flap is taken from the upper arm, with the cutaneous surface turned inward.

Israel ‡ has also devised an ingenious application of the Italian method, in accordance with which a flap may be taken from the lower part of the ulnar side of the forearm. (Fig. 472.) In this operation a portion of the ulna is included to give bony support. The pedicle of the flap is toward the elbow; and the free end, which is attached at the base of the nose, is taken from just above the wrist. The pedicle curves somewhat toward the posterior surface of the forearm.

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* Gesellschaft f. Chir., 1895, xxiv., 137.

† Arch. f. klin. Chir., 1894, xlviii., 179.

‡ Arch. f. klin. Chir., 1896, liii., 255.

When the flap is taken from the forearm the maintenance of the position is much less irksome than when it is taken from the upper arm. On the other hand, the skin of the forearm is thinner and has less subcutaneous fat than the skin of the upper arm, and therefore shrinks more. Most liberal allowance should in any case be made for shrinkage, in order to avoid tension not only on the flaps, but also, and more particularly, on the pedicle. It is also important to allow for shrinkage if we wish to secure good alæ and a good columna.

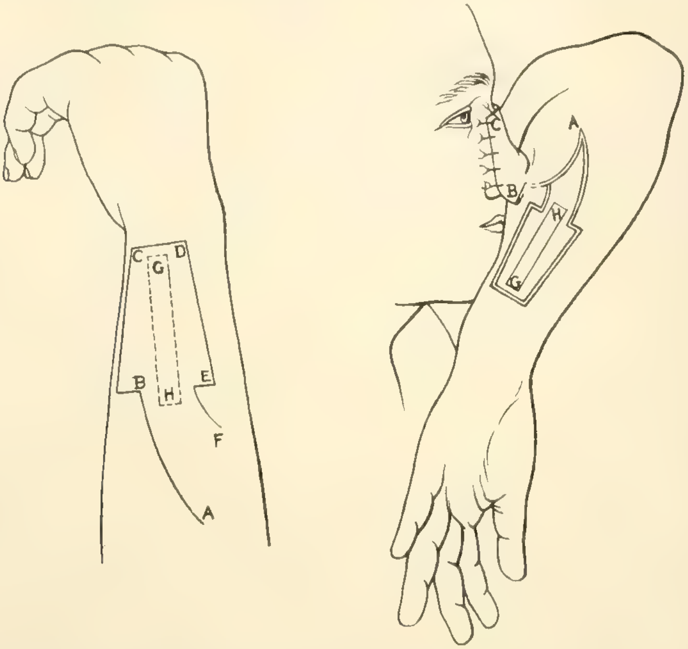

Fig. 472.—Operation of Israel. The flap *A B C D E F* is cut from the ulnar side of the forearm. The pedicle *A F* is a little toward the back of the forearm. A portion of the ulna is chiselled off and included in the flap *G H*, thus giving support to the skin.

The plan of utilizing a finger to form a new nose may, notwithstanding certain differences between the two, be regarded as a modification of the Italian method.

James Hardie,* in 1875, first used a finger in reconstructing a nose. He split the skin longitudinally along the palmar surface. At the base of this incision he made transverse cuts. Two lateral flaps were thus reflected and sutured to the margins of an incision made in the median line of the nose, after the finger had been placed inside the nose. This first operation was done for the purpose of correcting a saddle nose. The operation was not entirely successful, but since then similar operations have been performed by various operators with success.

Vredena,† in 1902, modified Hardie's operation by utilizing the proximal phalanx as a columna.

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* Brit. Med. Jour., 1875, ii., p. 393.

† Russk. Vrach, 1902, i, 717.

In these operations the finger was implanted into a gap in front of the nasal cavity.

Finney,* in 1907, described a new method of utilizing a finger by inserting it within the nose, underneath the skin which had been previously raised and refreshed on the under surface without external incision. He used the ring finger of the left hand. The nail and matrix were completely removed and the dorsum of the finger, as far as the distal end of the first phalanx, was denuded of skin. The skin from the entire tip of the finger was also removed, leaving the distal phalanx partially exposed. The retracted and deformed skin covering the nose was gradually freed from its attachments below without making any external incision. It was stretched forward by inserting a blunt instrument within the nose. The upper part was freed from the nasal process of the frontal bone, and the inner surface of the skin covering the front of the nose was denuded along the middle line. In order that the raw surfaces might lie in contact with the raw surfaces on the back of the finger, the tip was pushed within the nose until it rested on the nasal process of the frontal bone. It was held in place by sutures at the lower border of the nose. The finger was then fixed in position by strips of adhesive plaster and by plaster-of-Paris bandages. At the end of two weeks the finger was cut off at the metacarpo-phalangeal joint; at the end of another week the skin over the nasal spine of the superior maxilla was split, and the projecting proximal phalanx was flexed and its base inserted into the hole made. Thus a new columna was formed.

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Replacement of the Nose.

There have been several authenticated instances of replacement of the nose after it had been completely severed. Cases have been reported of replacement after the nose has been cut off as a form of punishment and after it has been severed in battle or in duels. Under circumstances in which such a course is possible the attempt should always be made to replace a severed nose, as everything is to be gained and nothing lost by the attempt.

There have also been numerous instances in which noses have been transplanted. Usually the nose was taken from an unfortunate slave, although there are instances in which brigands have robbed of his nose the first traveller whom they met, in order to replace the lost member of one of their company, which had been cut off as a punishment.

Myer, in 1881, completely detached a piece of skin from the forearm and transplanted it to form a new nose. Krause has similarly used pieces of detached skin to cover infolded flaps. The use of a piece of the ear to form a new ala is mentioned in the section on that subject.

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* Surgery, Gynecology, and Obstetrics, vol. v., p. 23.

Organic and Inorganic Supports.

Many methods of providing organic support for the new nose are mentioned in the detailed descriptions of the various operations. Ollier, in 1856, included with the flaps taken from the forehead a piece of periosteum. In some instances this has proved very satisfactory. Sufficient new bone has been formed from the transferred periosteum to give support to the flaps. On the other hand, in many cases the periosteal flap has proved useless, while in some instances the baring of the frontal bone has caused necrosis. In general, if support is to be taken from the frontal bone at all, it is wiser to remove a piece of the outer table rather than trust to the chance of new bone formation from periosteum.

The bone flaps have been cut in various ways. Koenig chiselled off a long narrow vertical strip with the overlying periosteum and skin, folded it down, and covered the whole with another flap turned down from the side of the forehead. Rotter folded down a much broader piece of bone, which was then split into three parts by two vertical cuts, for the purpose of forming the back and sides of the new nose. In order to prevent detachment of the overlying tissues from the bone, von Hacker, after marking out a flap on the forehead, drove two parallel rows of pins through the skin into the bone, one on each side of the median line of the flap. The superficial parts of the flap were next reflected up to the pins. The portion between the pins was then chiselled off.

The method by which a piece of the frontal bone may be sawed off is shown in the description of Nélaton's operation for repairing the loss of the lower part of the nose. (Fig. 485.)

If the bone flap is made long enough the lower end of it may, after it is placed in position, be broken off and bent backward to give firm support to the lower part of the septum.

Beside the pieces which have been chiselled from the frontal bone, other sources have been utilized for furnishing the desired support. Such are, for example, pieces taken from the tibia, pieces of costal cartilage, pieces of a metatarsal bone, the phalanges of a finger, pieces of the frontal bone of a rabbit, etc.

Numerous forms of removable supports have been used. Gutta percha, celluloid, silver, gold, hard rubber, and amber are among the materials. Such removable supports, however, are not, as a general thing, to be recommended. When it is decided to introduce an inorganic support that is intended to remain permanently in place, the form should vary with the necessities of the case. In cases of saddle nose, for example, a simple straight support may be introduced, but it should always be borne in mind that unless the tip of the nose be supported it may soon become flattened out by the pressure put upon it. Therefore in any case a support is to be preferred which has at least three points for bracing—one at the end of the nasal bone, and the other two upon the maxillary bones just outside the nares. There may be an additional point resting against the upper part of the maxillary bone at the base of the septum. If a support for the entire nose is necessary, narrow bands of silver or platinum, joined in the form of a cross, will be found to answer the purpose best. One arm of the cross, twice as long as either of the other three, is straight. The others curve sharply backward from the point of union. At the four ends of the cross small points should be fastened which may be sunk into the bony skeleton of the nose. The three short arms of the cross go, one through the septum, the other two through the alæ. The long arm goes up to the nasal bone.

Very many methods of insertion of a support have been used. It need only be said that the cavity into which the support is to be inserted must be dry and free from blood. It must be completely shut off from the nasal cavity behind and from the external air in front. If possible, no line of sutures should directly overlie the foreign body. Thus, the smaller the openings made the better, and the more complicated the operation the greater the chance of failure. Immediate failure is due usually to suppuration, in which case healing is practically impossible while the foreign body remains. Ultimate failure is due usually either to undue tension of the flaps, which leads to the formation of sloughs, or to accidental displacement of the support.

In view of the fact that failure of an attempt to insert permanent inorganic support may render other operations more difficult, the method now under consideration is one to be adopted only after most careful consideration.

Restoration of the Alæ.

In determining the best method of procedure to adopt in restoring an ala much depends upon the degree of destruction. The operation is greatly simplified if only a small remnant of projecting cartilage remains at the outer border of the nostril from which a flap may gain support. Under such conditions the tendency to cicatricial contraction of the nostril is greatly diminished and it is easy so to plan the operation as to give proper form to the outer edge of the ala.

In many of the minor defects of the ala it may be possible to turn into the gap to be filled an edge of the existing defect. In those instances in which the border of the defect is of proper shape and thickness and contains cartilage completely covered by well-nourished skin and mucous membrane, such an operation is most desirable. In this manner the new border of the ala—a point of the greatest importance—may be at once established.

In turning into the gap a flap which includes the whole thickness of the side of the nose there is produced a secondary defect which may be closed, according to its size and location, either by drawing together its borders or by folding or turning in flaps from neighboring parts. Obviously the thickness of the flaps at a point away from the free border of the nostril is of minor importance. So also it is not important whether the flaps which fill a secondary gap in the side of the nose do or do not contain cartilage. Cicatricial contraction will occur in the flap if no provision is made for an internal surface, and if this cicatricial contraction is extensive it will draw the free border of the nostril out of shape, but, in the milder cases, the likelihood of great deformity from this cause is slight.

Operation of Denonvilliers.—Numerous operations have been performed which fill the gap by means of skin taken from the nose itself. Denonvilliers* slid a flap of skin downward from the side of the nose, leaving a triangular area above to heal by granulation or be filled by grafting. The pedicle of such a flap may lie anteriorly at the tip of the nose or at the outer end toward the cheek.

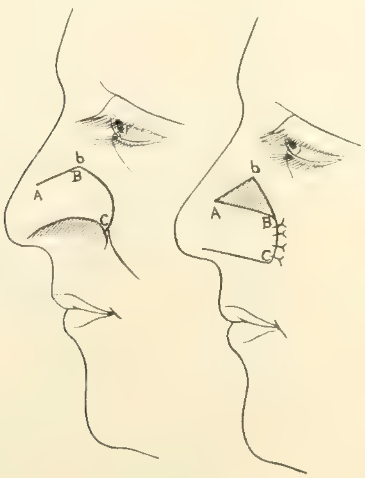

Fig. 473.

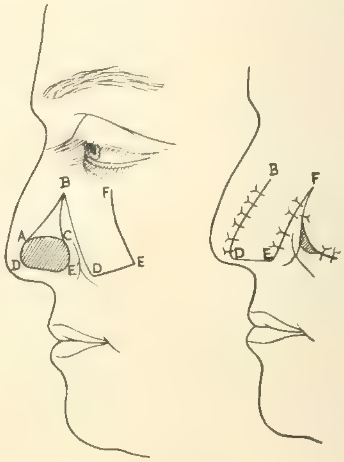

Fig. 474.

Fig. 473.—Operation of Denonvilliers. The defect in the ala is filled by lowering the flap *ABC*. The size of the secondary gap may be diminished by prolonging the incision *CB* upward beyond *b*, across the bridge of the nose.

Fig. 83.—Operation of A. Nélaton. The skin in the area *ABC*, just above the gap, should be excised or folded down on the line *AC* to form an inner layer. The upper part of the area of skin at the side of the nose and adjacent to the flap should be freed so that the point reaching up from *C* to *B* may be brought up toward *F* when the flap *BDEF* is jumped into position.

Better nutrition of the flap is assured when the pedicle is external. Mobility of the borders of the secondary gap may be attained by prolonging one of the incisions across the bridge of the nose and outward above the eyebrow of the opposite side. Thus the secondary gap may be made smaller at the expense of a longer scar. (Fig. 473.)

Langenbeck† has transferred a rectangular flap from the sound side of the nose to the side in which the gap existed. If this is done, the flap should, if possible, be jumped across a sound piece of skin at the tip of the nose.

Operation of A. Nelaton.—Nélaton‡ has taken a quadrilateral flap from the fold between the nose and cheek, but has left the pedicle above. (Fig. 474.) The operation is suitable when the defect extends far up into the nose. When the outer part of the ala is intact it may be necessary first to excise a small triangular area of skin directly above the gap. The flap is then swung in, across the small area of skin which is left at the side of the nose between the gap and the place from which the flap has been raised, and sutured into its new position. The triangle of skin between the point from which the flap was taken and the gap which was filled may be swung outward to help close the secondary gap. It may be possible to fold down rather than excise the area of skin just above the gap.

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* Verneuil: "Mém. de Chirurgie," t. i., p. 416.

† Szymanowski: "Handbuch der operativen Chirurgie," 1870, p. 327.

‡ Malgaigne: "Manuel de Méd. opératoire," 9th edition, ii., 155.

Operation of Thompson.—Thompson * has turned down a flap from the fold between the side of the nose and the cheek. In this operation the pedicle lies directly outside the nostril. The denuded area from which the flap is taken may be closed by direct suture. (Fig. 475.) The skin and subcutaneous tissues in this flap are so thin that great contraction would follow unless some firm support were provided underneath. The operation, furthermore, is not suitable for filling extensive gaps because of the tension put upon the lower eyelid. In order to give stiffness and to provide an internal surface for the flap Thompson has devised an ingenious method of splitting the septum from above downward and folding over into the gap the flap of mucous membrane and cartilage thus

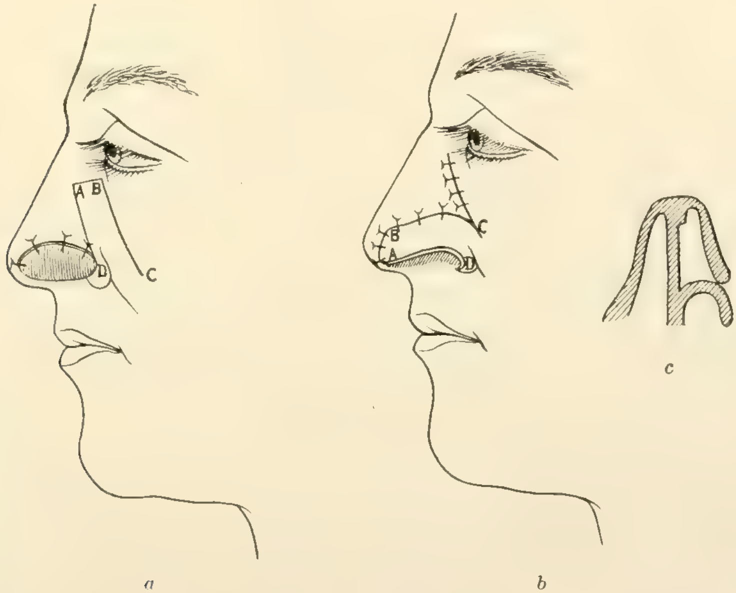

Fig. 475.—Operation of Thompson. In *a* the outlines of the cutaneous flap *DAB C* are shown, and the muco-cartilaginous flap may be seen folded down and sutured into position along the border of the defect; in *b* the skin flap is shown in position, covering the inner flap. The smaller diagram *c* represents the manner in which the muco-cartilaginous flap is folded down.

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* Dublin Hospital Gazette, 1855–56, ii., 212.

formed. The pedicle of this muco-cartilaginous flap is below, near the junction of the septum and the floor of the nose. Much technical skill is necessary to turn down this flap from above, without damaging the pedicle or in some other way impairing the nutrition to such an extent as to cause sloughing.

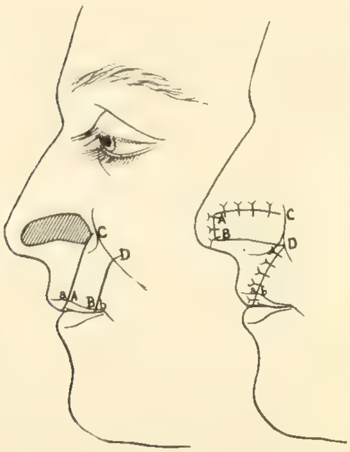

Fig. 476.—Operation of Bonnet. Method of taking a flap that includes the whole thickness of the upper lip.

Several other methods have been devised by which internal flaps may be provided. Flaps of skin may of course be folded in to take the place of the absent mucous membrane. Such flaps may usually be taken from the cheek just outside the nostril or from the side of the nose above the defect. The area from which these flaps are to be taken is to be determined largely by the advisability of covering the raw surface of the infolded flap with a second flap in accordance with any of the methods described. If such infolded flaps are not covered on their external surface, not only are the scars external and conspicuous, but, from their contraction, they tend to flatten and depress rather than round out the new ala. No special detailed description of such operations is required; it is enough to mention briefly that of Bouisson,* who folded into a defect in the ala a flap taken from the fold between the lip and the cheek just outside the gap. He covered the outer surface of this flap by drawing forward a second flap from a point immediately above and behind the first.

The Operation of Bonnet.—Bonnet† has provided an inner surface by utilizing a flap that included the whole thickness and height of the upper lip. The inner incision is carried from the outer corner of the nostril directly downward through the lip. The outer incision should start far enough outside the first to insure sufficient width of flap. It should extend downward to a point inside the corner of the mouth. (Fig. 476). The exact nature of the incisions is of course to be governed by the shape of the gap to be filled. The great objections to the operation are the disfigurement of the upper lip and the undue thickness of the new ala. Obviously, in men the operation would not be suitable because of the mustache. In women the disfigurement would be great.

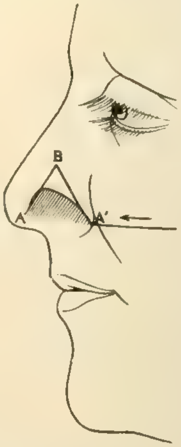

Fig. 477.—Operation of Mutter. A flap is drawn inward from the cheek.

Beck has taken a V-shaped piece in the same way, but he has done it in such a manner as to avoid disturbing the mucous border of the lip.

* Montpellier Médical, 1864, p. 128.

† Gaz. méd. de Paris, 1847, p. 610.

Weber* has taken from the central portion of the upper lip a flap suitable for filling a gap in the ala. The pedicle, in his operation, lies just below the septum. The flap is twisted into position and sutured there. Any undue closure of the nostril must be remedied by a secondary separation in which the pedicle is cut across. The nostril should not be completely closed at the first operation, because any retained secretions would be apt to prevent healing. The operation has little to commend it.

Mutter† has drawn a flap directly inward from the cheek. The sides of the defective ala are first refreshed by an inverted V-shaped incision. Then from the outer end of the V a horizontal incision is carried out upon the cheek. The corner of the flap of skin thus formed is drawn forward across the gap in the ala. (Fig. 477.) The objection to this operation is that it produces a tight bridge of skin which, to be sure, closes the gap, but at the same time produces a shapeless ala and causes an unsightly scar upon the cheek.

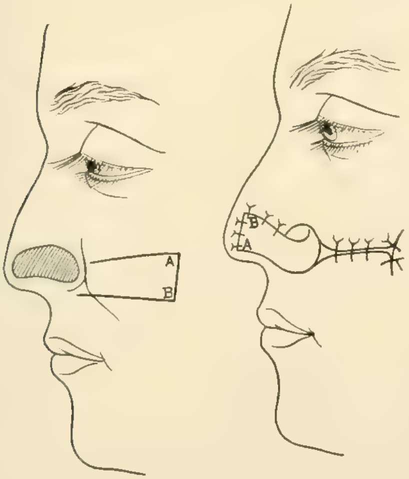

FIG. 478.

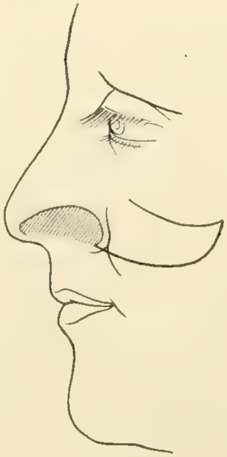

FIG. 479.

FIG. 478.—Operation of Sédillot. In this diagram neither incision enters the nostril. The free end of the flap is twisted downward to give a proper roll to the pedicle and to produce the prominence natural to the ala.

FIG. 479.—Fritz's Method of Making the Incisions that Free the Flap, which latter in turn is twisted downward as in the preceding figure.

In none of the operations already described is any special attention given to reproducing the prominent outer part of the ala. Dupuytren,‡ Sédillot,¶ Fritz, and Dieffenbach have performed operations similar in character, in which a flap of skin is taken from that part of the cheek which is outside of and below the ala, but above the fold which is normal in that region. (Figs. 478, 479, and 480.)

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* Szymanowski: "Handbuch der operativen Chir.," 1870, p. 333.

† American Medical Journal, 1838, p. 6.

‡ Labat: Ann. de la Méd. physiologique, 1833, xxiv., 814.

¶ Gaz. méd de Paris, 1844, p. 676.

The pedicle of the flap is to be just where the cheek should meet the absent ala. The flap may be elliptical, quadrilateral, or semilunar in shape. It must extend outward on to the cheek far enough to give ample length when it is twisted into its new position, and it must be wide enough to fill the gap after cicatricial contraction has occurred. Very abundant allowance of tissue is necessary in both breadth and length of flap. The pedicle is twisted in such a manner as to reproduce the shape of the normal ala. The inner edge of either the upper or the lower incision should usually enter the nostril. The end of the other incision must be far enough removed from the nostril to assure a pedicle large enough to nourish the flap. While the sweep outward of the ala is a little more pronounced when the lower incision enters the nostril, the nutrition of the flap is better assured if the lower incision is the shorter and the vessels coming up from the lower lip are not cut.

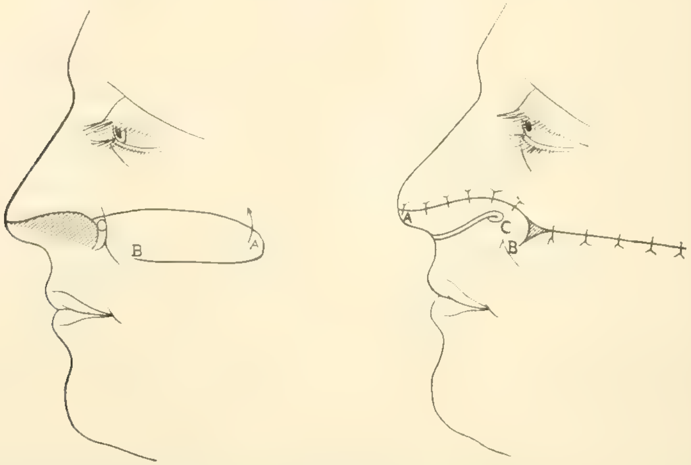

Fig. 480.—Another Operation of Sédillot. This differs from that shown in Fig. 473 in that the upper incision enters the nostril and that the flap is twisted upward rather than downward.

It is usually better to take the flap from a slightly lower area than is indicated in the diagrams, in order to follow a little more closely the natural lines of the face. Nélaton and Ombrédanne* lay down the following general rules of technique:—The flap should be 1 cm. ($\frac{2}{5}$ inch) longer than the area to be filled. The inner incision should start on the outer side of the gap to be filled, and should extend downward and outward along the fold between the lip and cheek. The outer incision should be 2.5 cm. (1 inch) higher up, and should end above at a point back of the middle of the spot where the ala should be. The pedicle of the flap should be between the ala and the upper end of the external incision. The flap is to be seized below and dissected up with the underlying fat. The tip of the flap is to be sutured to the front of the gap to be filled. What was originally the lower anterior border is to be sutured to the top of the gap. A stitch should unite the cheek directly back of the pedicle to the upper lip, and the remainder of the incision is then to be closed. In this manner the prominence of the ala is restored. The scar on the cheek follows a natural fold. As cicatrization advances, the skin is rolled into the nostril and forms a good border.

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* "La Rhinoplastie," p. 349.

In any case in which the avoidance of a scar is of the utmost importance the Italian method is to be preferred. The flap which is to fill the gap should be taken from the forearm. It should include the subcutaneous fat which will serve to make the new ala stand out properly. The pedicle should be very long indeed, as it undergoes marked contraction after it is cut across. If there is found to be tissue to spare, the extra skin may be turned in to line the flap, thus minimizing secondary contraction. In those more extreme cases in which the whole ala is destroyed, so that no vestige of cartilage remains above the naso-labial fold, this operation may very likely lead to subsequent atresia unless special precaution be taken. Under these conditions an operation in three stages is advised by Nélaton and Ombrédanne.* At the first sitting a flap is taken from the middle of the forearm and sutured to the upper lip below the nostril. This flap should be taken from the radial border in order to avoid the large number of veins on the anterior surface of the forearm. The flap should be sutured into an incision made obliquely downward and inward from the naso-labial fold just outside the destroyed ala to a point below the septum. (Fig. 481, *a*.) The skin side is to be uppermost.

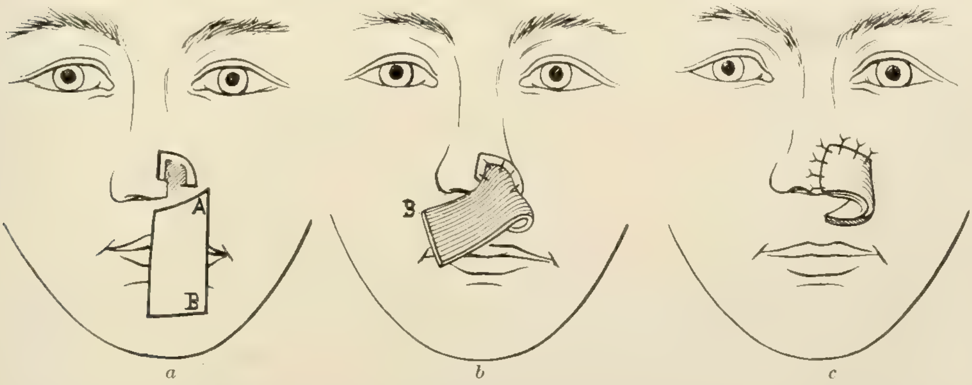

Fig. 481.—Operation of Nélaton and Ombrédanne. *a*, Skin flap from the forearm attached just below the nostril. Cutaneous surface is facing forward. *b*, Flap turned and folded in such a way that the external border *AB* is uppermost, and the cutaneous surface faces backward. The border of the skin is sutured to the refreshed edge of the mucous membrane. *c*, The flap is again folded upon itself so that it may cover the raw surface of the infolded portion. In time any superfluous tissue at the lower part may be trimmed away.

About two weeks later, the second step in the operation is performed. The pedicle is cut across, and the flap is sutured in place in the following manner, to form the new ala:—The edges of the nostril are refreshed, and the external border of the flap is also refreshed, twisted, and folded upward in such a manner that the cutaneous surface points inward. In this position the flap is united with the mucous membrane at the border of the nostril. (Fig. 481, *b*.) What was originally the inner edge of the flap is then folded upon itself and is sutured back to the skin around the edges of the gap. Thus the anterior and outer borders of the new nostril are established, but a certain amount of redundant tissue is left below. (Fig. 481, *c*.)

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* "La Rhinoplastie," p. 351.

At the third sitting, after the cicatrical contraction of the tissues is complete, any superfluous tissue below is excised. This last step should not be taken until several months have elapsed, in order that contraction may be complete.

The immediate transfer of a portion of the border of the external ear, without a pedicle, has been successfully accomplished, but it is a procedure of very doubtful value.

Restoration of the Lower Part of the Nose.

In restoring the tip of the nose it is important not to interfere in any way with the normal upper part. The Indian method is therefore not to be considered, nor are the French methods, in which the flaps are taken from the nose itself.

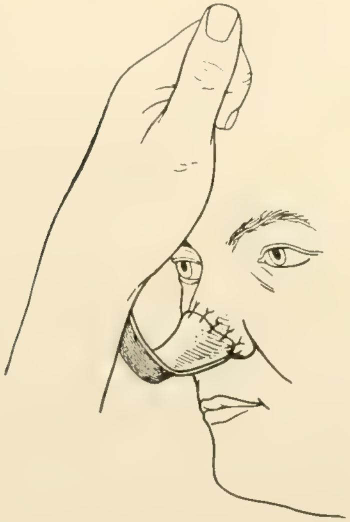
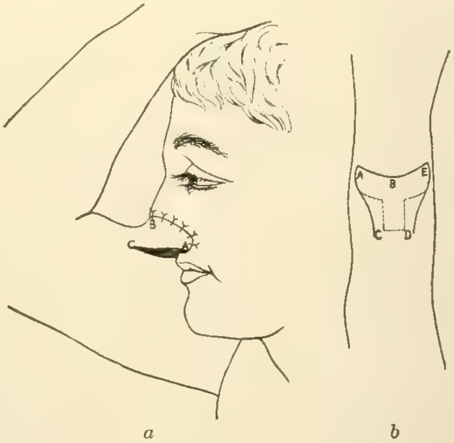


Fig. 482.



a *b*

Fig. 483.

Fig. 482.—Second Operation of Nélaton and Ombrédanne.* The tip of the nose is restored by a flap taken from the anterior surface of the forearm.

Fig. 483.—Third Operation of Nélaton and Ombrédanne.† *a*, The tip of the nose restored by a flap from the front of the forearm. *b*, The position of the flap on the arm is indicated. A portion of the pedicle is folded in to line the septum.

No flaps are to be taken which deform the mouth or lips, or draw the eyelids out of place. The scars produced should not be more disfiguring than the original deformity.

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* "La Rhinoplastie," pp. 307, 363.

† "La Rhinoplastie," p. 309.

The Italian method yields by far the best results, and is usually to be recommended. When the alæ at the sides of the nose remain intact, a single flap taken from the arm or forearm may be sufficient. (Figs. 482 and 483.) But when the destruction is at all extensive, an internal as well as an external flap must be provided in order to prevent undue cicatricial contraction.

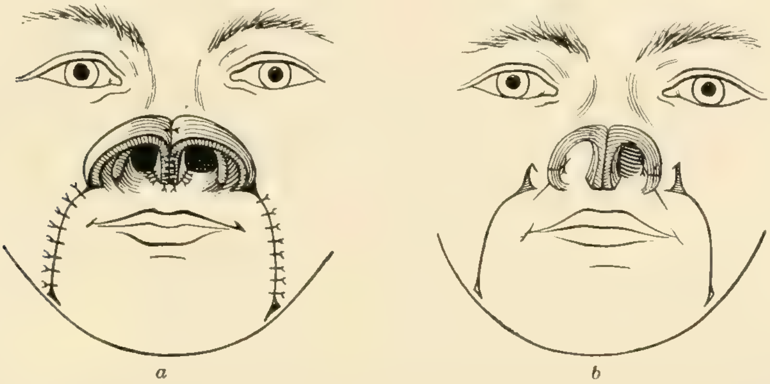

FIG. 484.—Operation of Bayer. *a*, The flaps are folded in to make a new tip of the nose and a new septum. The remnants of the alæ are within the infolded flaps. *b*, At a second stage the pedicles are cut across and the flaps are joined to the alæ.

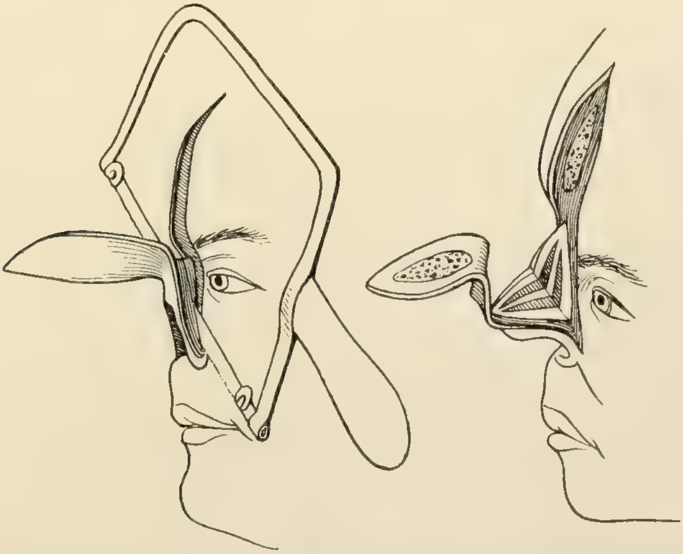

FIG. 485.—Operation of Ch. Nélaton. (After Nélaton and Ombrédanne.) These diagrams illustrate the method by which a thin layer may be sawed from the outer table of the frontal bone with the skin flap, and also the manner in which portions of the nasal bones and cartilages may be sawed through to be depressed to form a firm support for the reconstructed lower part of the nose.

When the loss is not too great, the internal flap may be provided by folding down a flap from the nose itself without materially increasing the resulting scar. In larger defects of the lower end of the nose, however, the operation of Bayer[*] (Fig. 484) is to be recommended.

The Operation of Bayer.—On each side a flap is formed which curves down, from a point just outside the ala, along the fold between the cheek and the lip. These flaps should be taken from just outside the corners of the mouth. Their width should correspond to the height which is to be added to the tip of the nose. Their length should be sufficient, when folded over, to form new alæ and a new septum. They should thus extend down at least as far as the alveolar process. At the first operation they are folded in and their new surfaces are sutured together to form the new septum. When the sides of the alæ remain intact the flaps are to be folded in outside of them. Three weeks later the pedicles of the flaps are to be cut across, and they are to be united to the remnants of the alæ. At the same time, the external surface may be covered by a flap from the arm or forearm. An objection to the operation is that some of the muscles about the mouth and the nerves which supply them are likely to be cut.

Ollier,[†] Neumann, and Nélaton[‡] have all repaired the loss of the lower part of the nose by depressing the upper border of the defect, including with the flaps more or less bone or cartilage. The most elaborate operation is that of Nélaton. (Fig. 485.)

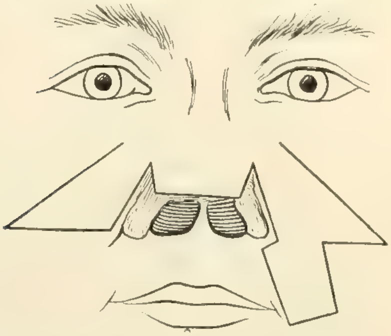

Fig. 486.—Operation of Szymanowski for Repairing the Loss of the Lower End of the Nose by Flaps Taken from the Cheeks.

Operation of Ch. Nélaton.—A long inverted V-shaped flap is cut from the nose and forehead. The apex of the V is just at the border of the hair in the middle of the forehead. The arms of the inverted V should spread as widely as the eyes will permit. They should extend downward, along the folds between the nose and cheeks, to points outside the alæ. They should keep well outside any gap in the nose and should, below, leave enough tissue between the defect and the incisions to assure proper nutrition of the flap. With the flap there must be included a portion of the nasal bones and cartilages, which portion is to be folded down to give firm support to the new lower part of the nose. There may also be included a piece of the frontal bone, which will take the place of any bone removed from the upper part of the nose. The diagrams (Fig. 485) illustrate well the method of operation. Obviously in milder cases less extensive operation will be required.

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[*] Bayer, in Prager med. Wochenschr., 1888, xiii., 77.

[†] Gaz. hebd. Méd. et Chir. 1860, p. 50; Compte rendu de la Soc. des Sciences méd. de Lyon, 1861–62, 300.

[‡] Bull. de la Soc. de Chir., Paris, 1900, p. 665.

This operation involves some of the most useful methods employed in rhinoplasty.

Szymanowski* has taken flaps from the cheeks in order to restore the tip of the nose. The flaps should be rhomboidal in shape, with their pedicles above, directly outside the upper part of the defect in the nose. Enough tissue should be included in one or both flaps to form a new septum. (Fig. 486.)

Rouge has restored the tip of the nose by drawing down a flap from a point immediately above the gap. The flap may be left attached at both sides. A secondary gap is of course thus left above the original defect.

Repair of the Lower Part of the Septum.

The loss of the lower part of the septum is often very disfiguring. In those cases in which the loss is not sufficient to have led to depression of the tip of the nose, correction of the deformity is relatively simple.

Operation of Dupuytren.—Dupuytren† took a quadrilateral or triangular flap from the central part of the upper lip. This flap included the skin and underlying tissues, but left the mucous membrane intact, the pedicle being just at the base of the septum. In this operation the flap is twisted and turned up through an angle of ninety degrees, so that the lower end can be attached to the tip of the nose. By carrying the incision at the border of the pedicle slightly higher on one side than on the other, the flap may be more easily brought into place; and the portion most plainly visible will, later on, be skin rather than scar tissue. The gap in the upper lip is, of course at once closed by sutures. (Fig. 487.)

Operation of Serre.—Serre‡ has taken a flap from exactly the same area as Dupuytren. (Fig. 488.) The pedicle, however, is left at the red border of the lip. The free upper end of the flap is sutured to the end of the nose. At a second operation the pedicle at the red border of the lip is cut across, and sutured back between the nostrils. The advantage of the operation is that the two sides are perfectly symmetrical; the disadvantage is that, while in Dupuytren's operation the incision in the upper lip may be sutured at once, in that of Serre immediate suture of the lip is impossible.

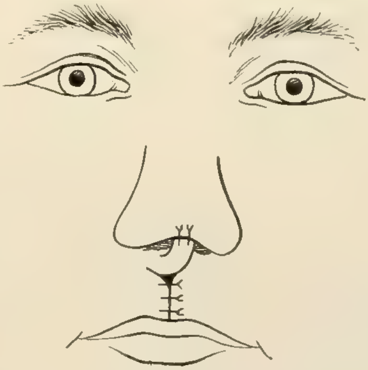

Fig. 487.—Operation of Dupuytren. A flap is turned up from the middle of the upper lip.

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* "Handbuch der operativen Chir.," 1870, S. 314.

† Marx, in Jour. hebd. de Méd. et Chir. pratiques, 1833, p. 29.

‡ "Traité sur l'Art de restaurer les Difformités de la Face." Montpellier, 1842.

Operation of Lexer.*—A flap of mucous membrane alone may be taken from the inner surface of the same part of the lip. The pedicle of such a flap is to be above at the base of the septum. The flap is to be drawn out through a short horizontal incision just at the point where the lip and septum should meet. Thus a mucous flap is folded forward through a hole in the lip. No noticeable scar is made in the lip. The sole objection to the operation is that the exposed surface of the septum consists of mucous membrane rather than of skin; but in time such an exposed area will assume largely the color and character of skin.

Dieffenbach has taken a rectangular flap horizontally from the upper lip and turned it up to form a new septum; but the procedure is very objectionable, because it cuts across the natural lines of the upper lip, and is very likely to produce marked asymmetry.

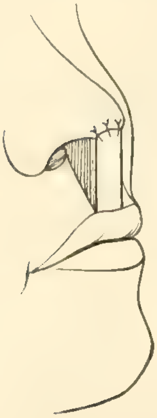

Fig. 488.—Operation of Serre. The flap is sutured to the tip of the nose. It should later be cut across at the pedicle at the border of the lip.

Demons has taken two rectangular flaps, one from below each nostril, and separated by the median portion of the lip. The pedicles of the flaps are above. The flaps are turned up in much the same manner as in the operation of Dupuytren, but the raw surfaces of the two flaps are apposed. Thus, the line of union between the two is in the median line, while the skin surfaces line the inner borders of the nostrils and meet below at the free lower edge of the septum.

The folding up of a flap that includes the entire thickness of the upper lip, as done by Blandin, is not to be considered if other similar, less severe operations are possible.

The Operation of Raoult.—The operation of Raoult† should be mentioned because it may be of value in exceptional cases. A curved incision is made on each side, starting at the lower border of the nostril and curving outward close below the alæ, and then upward close outside the alæ. Second incisions are then made on each side. These incisions start in the median line and curve downward and outward toward the free margin of the lip in lines diverging somewhat from those of the first incisions. Thus two flaps are freed, which may be drawn forward, upward, and inward. They are to be united to form the new septum above the undisturbed central portion of the upper lip. (Fig. 489.) There is one very serious objection to such an operation, viz., that the tension of the flaps is likely to flatten the tip of the nose.

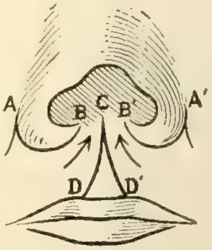

Fig. 489.—Operation of Raoult. The incisions *AB* and *A'B'* encircle the alæ. The incisions *CD* and *CD'* leave undisturbed the central part of the upper lip. The two flaps between the incisions are to be slid forward and inward to make a new lower portion of the septum.

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* Deutsche Zeitschrift f. Chir., March, 1906.

† Presse médicale, April 1st, 1903.

Operation of Labat.—Labat* has described an ingenious adaptation of the Italian operation, by which a bit of skin of the thenar eminence of the left hand is attached to the tip of the nose, later to be severed and fastened to the upper margin of the lip. The hand is to be fixed palm forward with the thumb on one side of the nose and the fingers on the other. (Fig. 490.)

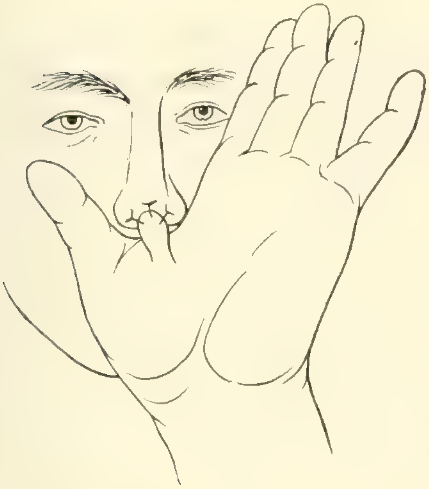
Fig. 490.—Operation of Labat for Restoring the Lower Part of the Septum.

The operations just described do not in any way give support to the tip of the nose.

Among the earlier operations intended, through the use of double flaps, to prevent contraction of the nostrils was that of Sédillot, who, having folded up a flap from the median portion of the upper lip, united it with the tip of a frontal flap to form by a double layer of skin a firmer lower part of the septum. Such a support, however, must at best be unsatisfactory.

Nélaton has reversed the order of the flaps; he folds one up from the upper lip, with the raw surface downward, and places below it a flap cut from the inner surface of the nose and folded down.

Second Operation of Ch. Nélaton.—Nélaton* has described a useful operation which gives a bony or cartilaginous support to the new septum and holds forward the tip of the nose. A small curved incision with the convexity downward is made just below the base of the septum. This incision is carried through the soft parts down to the superior maxilla above the alveolar process. A gouge is then driven backward and upward in the median line, and is made to enter the nasal fossæ far enough back to cut off a portion of the rudimentary septum; the piece cut off should be large enough to enable it to be folded forward and downward so that the posterior portion, which has been freed, shall meet the tip of the nose. It is then sutured into position. (Fig. 491.) The nutrition of this piece of bone or cartilage, covered on its exposed surface by mucous membrane, is preserved through the soft parts which are undisturbed at the inner side of each nostril, directly above the ends of the original skin

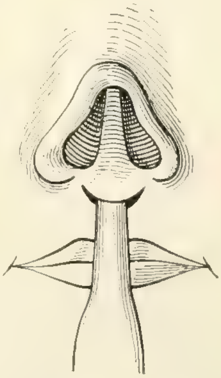
Fig. 491. — Second Operation of Ch. Nélaton. The gouge is introduced through the curved incision, and enough of the remaining septum is cut off to make a new support for the tip of the nose when it is folded forward.

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* Annales de la Méd. physiologique, Paris, 1834, xxv., 56.

† Duvernoy: Thèse, Paris, 1900, p. 48; "La Rhinoplastie," p. 383.

incision. The direction in which the gouge is inserted depends, of course, upon the extent to which the septum is destroyed, and also upon the length of the flap which is to be folded forward.

SADDLE NOSE.

Various alterations in the shape of the nose occur as a result of more or less complete destruction of the bony or cartilaginous supports. The flattening of the central portion which results, may be due to syphilitic or tuberculous lesions; while, more rarely, it is due to the abuse of cocaine, to traumatism, or to caries not of specific origin. Occasionally the deformity is congenital. The general knowledge that the deformity usually results from syphilis makes patients peculiarly anxious to be benefited.

Marked variations in the deformity are observed. Three general types of saddle nose may, however, be distinguished. In the first, the deformity is either congenital or the result of fracture. There is a flattening of the bridge of the nose, but there is not destruction due to disease. In the second type, the loss of tissue is chiefly in the cartilage, with more or less complete preservation of the bones. In the third type, both cartilage and bone are destroyed. According to the extent of the destruction there follows a tilting up of the tip of the nose, which makes the nostrils point more or less directly forward. The deformity has been called the "lorgnette nose." In every case the treatment must depend both on the amount of the depression of the bridge and the degree of tilting upward of the tip.

Operations have been divided arbitrarily into two groups:—in one, the object is to raise the depression, while in the other the tip of the nose is lowered. The distinction is not one of great practical importance. The important point is that, in operations in which the tip of the nose is lowered, the nasal cavity should in most cases be opened from the front, and the gap thus created should be filled by a flap of mucous membrane or skin which faces inward. In operations in which the tip of the nose is not to be depressed, the nasal cavity need not be opened.

In determining the method of treatment the mobility of the skin about the depressed area is an all-important factor. In most cases the skin is not sound, is closely adherent to the underlying tissues, and is not elastic. This is especially true in the syphilitic cases. In them the depression is due to widespread loss of the deeper tissues with consequent extensive and deep scar formation.

In those milder cases in which the elevation of the tip of the nose may be disregarded the problem is relatively simple, especially when the skin is movable. In such cases prosthetic injections are particularly valuable, because they leave no noticeable scar, and at the same time furnish a permanent support under the skin. Such injections, however, are not to be considered in cases in which the skin is closely bound down to the sunken bridge by firm scar formation. In such cases there is no cellular tissue into which the injection may flow, and, if the operator is successful in forcing the injection into the scar, sloughs must inevitably result. It may be possible, however, in some instances to free the skin at a preliminary operation, thus creating a pocket into which material may be injected, or into which some inorganic support may be inserted.

If prosthetic injections or supports are inadvisable, the choice of operation must depend upon the degree and character of the deformity, the soundness of the neighboring skin, and the amount of importance which the patient attaches to visible scars.

As far as is possible, incisions should be confined to the root of the nose, where the scar lies in the skin folds that run between the eyebrows; or they should be made just within the lower free border of the nostrils. Scars along the nasolabial folds are inconspicuous. Scars may be necessary along the fold between the nose and the cheek. Scars on the back of the nose are particularly objectionable.

Operations which involve a change in position of the soft parts alone, and in which no new tissue is inserted to fill the depression, are of only temporary benefit; yet a few may be mentioned very briefly. The operation of Ferguson, for example, is of this type. An incision is made within the nostrils, through which the sides and back of the nose are raised and also are freed from the cheeks by dissecting under them and separating them from the superior maxillæ for a distance sufficient to allow the introduction of the finger within the nose. This is then moulded into proper shape and is held forward by two silver pins passed through from side to side on a level with the cheeks. After ten or twelve days the position of the pins is changed to prevent undue scarring from cutting. In time, after the removal of the pins, a nose thus pushed forward must inevitably sink back into its former position unless some additional support is provided.

Dieffenbach has dissected a median and two lateral flaps of skin, and has brought the edges together in such a manner as to fill the depression. The operation is essentially similar to that of Ferguson, but it involves more external incisions and for that reason is not to be recommended.

Dieffenbach has also attempted to remedy the deformity by means of variously placed skin incisions, which were afterward sutured in special ways, as well as drawing the skin across the depression, as the chord of an arc. Such a procedure, it seems scarcely necessary to add, is useless.

In another form of operation, Dieffenbach* "underplanted" a flap of skin to fill in the depression. By an inverted U-shaped incision a flap of skin is turned down from over the depressed bridge. Beneath this a second flap is folded down from the forehead. The pedicle of this latter flap is just above the apex of the first flap. The support thus made is permanent, but the tip of the nose is not lowered, and conspicuous scars are created. This operation is very similar to, but not so complete as, that of Nélaton and Ombrédanne, to be described later.

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* "Oper. Chir.," i., 359.

The essential points in any satisfactory operation for the correction of a pronounced saddle nose are these:—First, to lower the tip of the nose; second, to close the opening formed into the nasal fossæ with an inner flap, the cutaneous surface of which faces inward; third, to make the outer flap of greater area than that which originally covered the space; fourth, to have between the two flaps a firm support, preferably of cartilage. In order to fulfil these conditions each individual case must be studied with the utmost care.

Although, in the treatment of saddle nose, flaps of skin alone are very seldom sufficient, there are certain methods which, while they do not fulfil the requirements just enumerated, are nevertheless worthy of being mentioned because of their suggestiveness, and because in exceptional circumstances they may prove sufficient, if combined with other procedures. The merits of these different operative methods vary greatly. If any one of them were really satisfactory the others would never have been devised.

The following are the methods in question:—

Operation of von Mangold.*—Von Mangold excised, with its perichondrium, a bit of the seventh costal cartilage 4 or 5 cm. ($1\frac{3}{5}$ to 2 in.) long, 1 cm. ($\frac{2}{5}$ in.) wide, and 0.5 cm. ($\frac{1}{5}$ in.) thick. Then, having made a short transverse incision between the eyebrows, he introduced into this opening a sound and passed it down through the subcutaneous tissues as far as the tip of the nose, thus preparing, as it were, a channel into which he afterward pushed the fragment of cartilage the whole distance. In doing this he was careful to keep the side which is covered with perichondrium toward the skin. Two other little pieces of cartilage may, if necessary, be pushed into the alæ through small incisions in the folds on each side of the nose. The cuts are closed by sutures. If the operation is successful, all the pieces of cartilage are allowed to remain. The alæ do not flatten, and the depression in the bridge is prevented. After several months the length of the nose may be increased. The nose with the costal cartilage is freed by an incision having the shape of an inverted V, the point of which is just above the upper border of the cartilage. The lower part of the nose may then be depressed and held in position by pressing the upper end of the cartilage into a notch cut in the nasal bone. The nose is thus elongated and resumes its normal profile. The incision, originally V-shaped, may be closed as an inverted Y.

Israel and De Page have operated in very similar ways.

Operation of Israel.—Israel makes a median incision about 2 cm. ($\frac{4}{5}$ in.) long, at the point of the depression. By subcutaneous dissection he divides any cicatricial adhesions that may be present, and separates the skin at the sides from the maxillary bones. In order to obtain the normal profile he depresses the tip of the nose. In this dissection it is necessary to free the flaps thoroughly, so as to permit their being reunited without traction. Then a spicule of bone, about 0.5 cm. ($\frac{1}{5}$ in.) thick and 3 cm. ($1\frac{1}{5}$ in.) long, is taken from the crest of the tibia. If necessary, incisions are made in the subcutaneous tissue at each side to receive the piece of bone. Once the fragment is in place, the upper point of the bone is engaged solidly in subcutaneous tissue over the bridge of the nose, while the lower point is buried inside the skin of the lobule. The nose resumes its normal profile. The edges of the incision are sutured over the new support.

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* Gesellschaft f. Chir., Berlin, 1900, xxix., 460.

Operation of De Page.—The operation of De Page differs from that of Israel only in minor details. The spicule of bone taken is longer, and from 3 to 4 cm. (1 to $1\frac{1}{2}$ in.) wide. This piece of bone is split lengthwise so that it may be folded like a roof. It is then pushed under the skin of the nose, which is sutured over it. Silver wire may be passed through and through to maintain the proper shape for some days, and to relieve tension until union is firm.

In neither of these operations should the incisions enter the nasal cavity.

Fourth Operation of Nélaton and Ombrédanne.—Nélaton and Ombrédanne,* in what they regard as the method of choice in the more severe cases (Figs. 492, 493, and 494), have selected points from various operations.

At a preliminary operation they insert, beneath the skin of the forehead, exactly vertically and exactly in the median line, a piece of the eighth costal cartilage about 4.5 cm. to 5 cm. ($1\frac{3}{4}$ to 2 in.) long. This may be done through a small incision at the edge of the hair. Six weeks later an inverted U-shaped incision is carried across the lower part of the forehead. The arms of the Λ spread out to the inner ends of the eyebrows. The middle reaches as far above the eyebrows as it is desired to depress the tip of the nose—usually about 2 cm. ($\frac{4}{5}$ in.). The ends of the incision are carried downward as far apart as the eyes permit, and then along the fold between the nose and cheeks to points just above the alæ. The flap thus marked out is dissected free and folded down from above. At a point about 1.5 cm. ($\frac{3}{5}$ in.) above the tip of the nose, a transverse incision is made directly into the nasal fossæ, so that the tip of the nose may be depressed. The flap will then reach only to the level of the eyebrows.

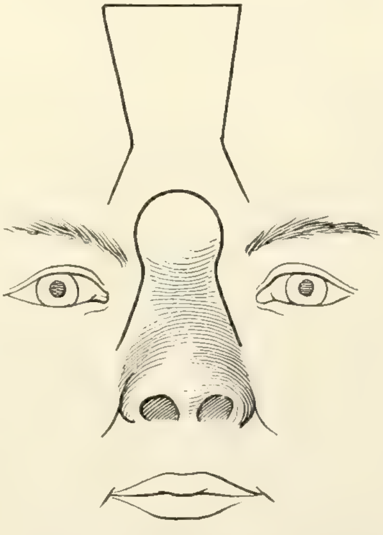

Fig. 492.—Fourth Operation of Nélaton and Ombrédanne, First Stage. Lines of incisions for the two flaps are indicated.

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* "La Rhinoplastie," p. 284.

A second flap, which includes the piece of implanted cartilage, is then folded down from the forehead. The upper end, which is close to the end of the piece of cartilage, should be at the border of the hair. The sides converge somewhat from above downward for a little more than half their height. Then they spread again in order that enough tissue to insure nutrition may remain outside the area from which the first flap was taken. This flap is freed and folded downward underneath the first flap. The freed upper end should just meet the depressed tip of the nose. The cutaneous surface faces inward. The epidermis may be removed at those points where it does not line the opened nasal fossæ. The first flap may then be replaced outside the second.

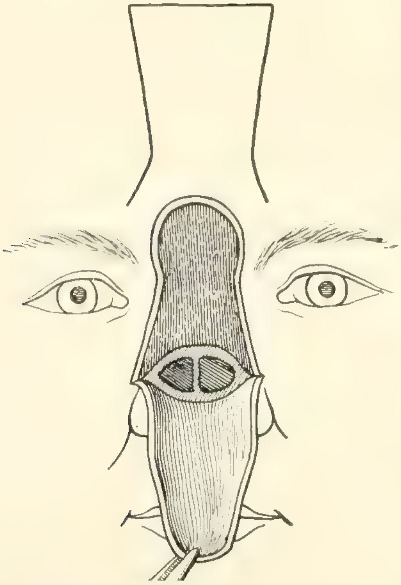
Fig. 493.—Fourth Operation of Nélaton and Ombrédanne, Second Stage. The first flap is folded down and the tip of the nose is lowered by a free transverse incision through cartilage and septum.

At a third operation, about fifteen days later, the pedicle of the second flap may be cut across and Thiersch grafts placed upon the granulating area on the forehead.

Operation of Czerny.—Czerny* has made a support for the skin in an entirely different manner, by utilizing the sunken cartilage itself. By a median incision the skin is dissected free from the back and sides of the nose through nearly the entire length. While the skin flaps are pulled aside (Fig. 495) two semi-elliptical incisions are made through the sunken cartilage into the nostrils on each side of the septum. The incisions are curved with the convexity backward. The distance from the median line to each incision should be slightly greater than the depression which is to be remedied. Two cartilaginous flaps are thus formed, one on each side of the septum. The inner surface of each is covered with mucous membrane. The flaps are then bent forward so that their external surfaces lie back to back and in contact in the sagittal plane of the nose. In cross-section the car-

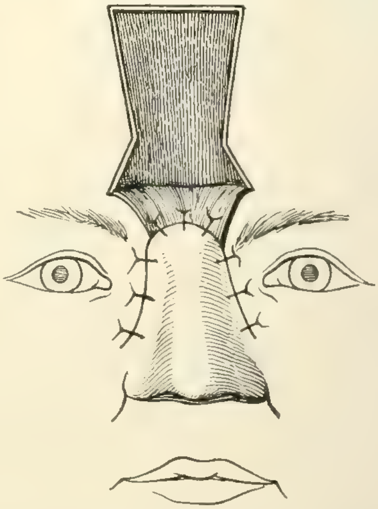
Fig. 494.—Fourth Operation of Nélaton and Ombrédanne, Third Stage. The second flap is folded down and the first flap is replaced outside it. The gap in the forehead still remains to be filled in.

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*Gesellschaft f. Chir., Berlin, 1895, xxiv., ii., 212.

tilage is bent into the shape of a tuning-fork. Their nutrition is assured by their connection with the septum, which is not disturbed. The free borders of the skin are reunited. A suture may be passed through the nose for a few days to keep the sides pressed together.

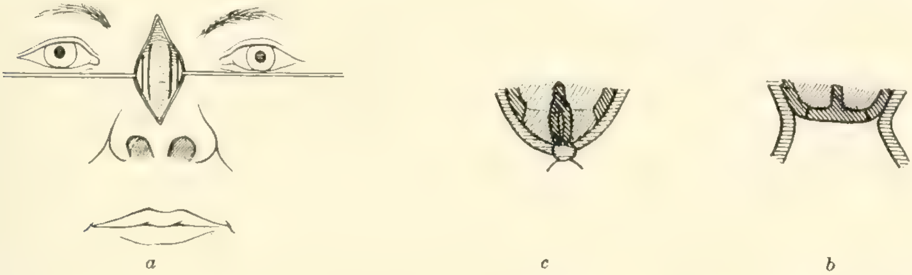

Fig. 495.—Operation of Czerny. In *a* the skin is retracted to show the incisions through the cartilage. (The two vertical ones in the middle, instead of representing nearly parallel lines, should together form an incomplete ellipse.) In *b* a cross-section of the depressed nose is shown, with the skin retracted and the lines of incision through the cartilage indicated. In *c* the cartilaginous flaps are bent forward and the skin is united over them.

Operation of Mikulicz.—The operation of Mikulicz is of very doubtful benefit. It is an elaboration of the method of Czerny. Incisions are first carried from the upper part of the depressed bridge of the nose downward and outward along the fold between the cheek and the nose and through the ala into the nostril. These cuts are made on each side. The flaps thus formed are attached below at the base of the septum and above at the bridge of the nose. They are then folded forward so that their mucous surfaces shall face outward. The skin surfaces are placed back to back, forming at the same time a septum and a buttress against which a flap turned down from the forehead may rest. The epidermis may be removed from the two apposed surfaces of the flaps. If possible, at least a portion of the ala should be left attached to the cheek to give shape to the new nose, which must inevitably tend to contract as its inner raw surface cicatrizes.

The operation is complicated and has little to commend it.

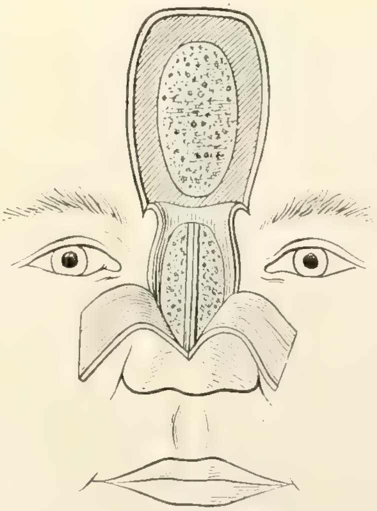

Fig. 496.—Operation of Schimmelbusch. The skin covering the nose is retracted in two flaps, and the tip of the nose is lowered by a transverse cut. In the diagram the flap from the forehead is folded into position to fill the gap. The piece of bone in the flap is split longitudinally so that it may be folded into shape. The nasal flaps are to be replaced.

Schimmelbusch and Trendelenburg have gained support by folding down from the forehead flaps that include skin, periosteum, and bone.

Operation of Schimmelbusch.*—Two triangular flaps with their bases below are turned down to expose the sunken portion of the nose. (Fig. 496.) By a transverse incision the tip of the nose may be lowered. An elliptical flap is then folded down from the forehead, a portion of the outer plate of the frontal bone being left attached. The pedicle of this flap lies between the eyebrows, just above the tip of the first incision. The bone in the flap is then split in the median line and each side is folded backward so as to give shape to the nose. The lower ends of the bony flaps are pushed down toward the alæ. The original skin flaps are then to be united outside the flaps turned down from the forehead. At a later operation the pedicle of the upper flap may be severed and any granulating areas covered by Thiersch grafts. A great disadvantage in the operation lies in the difficulty—amounting perhaps to impossibility—of uniting the original flaps outside the flap from the forehead.

Operation of Trendelenburg.—The operation of Trendelenburg † is similar to that of Schimmelbusch. Flaps are turned down from the bridge and sides of the nose, and the tip is depressed in the same way. An elliptical flap of skin, periosteum, and bone is taken from the forehead. The flap, however, instead of being folded down, is turned down and inserted edgewise within the nose through an incision made in the median line. This flap thus makes a new septum which projects forward, and in front of which the skin flaps must be united. In order that the flap may be turned easily, the pedicle of the flap taken from the forehead must be at one side of the median line and obliquely placed. (Fig. 497.) The same difficulty that is experienced in the Schimmelbusch operation—viz., in making the external skin flaps meet in front—arises in this operation, although in less degree.

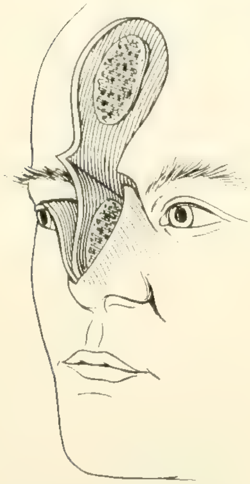

Fig. 497.—Operation of Trendelenburg. The flap from the forehead is inserted edgewise into the nose. Thus a new supporting septum is formed.

Operation of Helferich.‡—An inverted U-shaped incision is carried across the bridge of the nose and downward on either side as far as the alæ. The skin within this area is folded downward and the lower cartilaginous portion of the nose is separated from the bone by a transverse cut and drawn downward. A flap, including a piece of periosteum and bone sufficient to form a new bridge to the nose, is then turned down from the forehead. The flap folded down from the nose is replaced to cover over the lower portion of the flap folded from the forehead. The upper part of the frontal flap is left with a raw surface exposed. At a second operation the pedicle of the latter flap may be severed and folded upon itself in such a manner as to meet the upper end of the flap covering the tip of the nose and to cover the raw surface above it. Later still, the upper fold in the flap from the forehead may be trimmed and fitted accurately. (Fig. 498.) The operation thus involves three stages, and the resulting scar is complicated. At times, however, it may be found that some such procedure as this is required for covering the upper part of the nose, if the intention had been to cover in the bridge of the nose with the original skin flaps as described in the operation of Schimmelbusch.

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* Gesellschaft f. Chir., Berlin, 1895, xxiv., 342.

† Arch. f. klin. Chir., 1895, L., iv., 739.

‡ Gesellschaft f. Chir., 1888, xvii., 108.

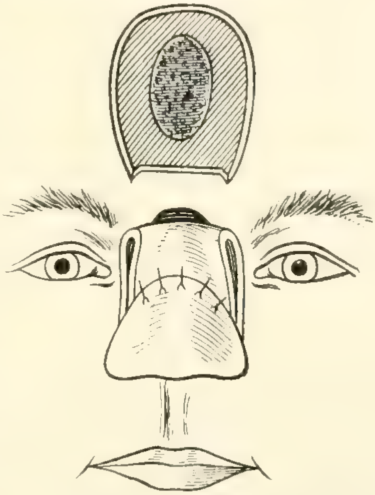

FIG. 498.—Operation of Helferich; Second Stage. The pedicle of the frontal flap is cut across and folded upon itself to cover the raw surface originally left above the nasal flap.

OPERATION OF ISRAEL.*—By a transverse incision the lower part of the nose is depressed. Then a narrow vertical flap, including skin, periosteum, and bone, is folded down from the forehead. After this flap has been lowered to its proper place, it is fastened to the tip of the nose. Thus a bridge is formed, with a passage underneath, reaching across the depression. The anterior surface of this bridge, at first consisting of exposed bone, is finally covered in by cicatricial tissue, which draws the skin forward from what has become the posterior surface of the median flap. The skin covering the depressed bridge of the nose is then drawn forward on each side and united to the tissues that cover the bone of the new bridge. What was originally the skin of the forehead is at the same time turned inward to act as a lining membrane for the nasal cavity.

OPERATION OF NEUMANN AND SZYMANOWSKI.†—A long inverted V-shaped incision is made with the apex in the middle of the forehead and the arms extending down on either side of the bridge of the nose and out upon the cheeks just above the alæ. The skin flap is turned down and a transverse cut is made separating the cartilaginous from the bony portion of the nose. The cartilaginous portion is then lowered and the incision is sewed up in the shape of an inverted Y. There is liability that the apex of the flap, if cut into too much of a point, will slough, but the fundamental objection to the operation is that the central portion of the nose is left without any support except the skin. This method of forming the skin flaps may of course be used in connection with the insertion of some support in the middle of the nose. It may well be modified somewhat by including with the skin flap a piece of bone from the forehead, or from the upper part of the nose, or from both regions, as is done in the operation of

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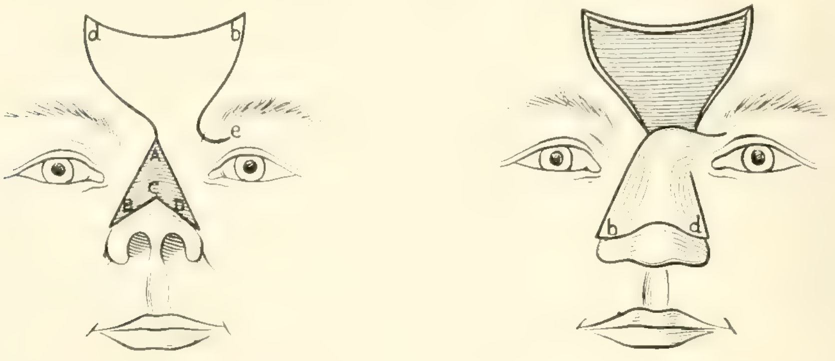
* Gesellschaft f. Chir., 1887, xvi., 85.

† "Handbuch der operativen Chir.," 1870, 331.

Nélaton* for partial destruction of the nose. Under these conditions the piece of bone from the upper part of the bridge of the nose should be carried down toward the tip, and the piece from the frontal bone should replace that moved down from the upper part of the bridge.

Operations of Dieffenbach and Langenbeck.—The operations of Dieffenbach and Langenbeck† are essentially the same. Incisions, which start at the glabella and extend downward toward the alæ, are made in the form of an inverted V. Any unsound skin over the bridge of the nose may be excised; and then, if necessary, an incision may be made through the cartilage of the nose, in the one case transversely and in the other in the form of a flattened and inverted V, in order that the point of the nose may be depressed. Flaps are then turned down from the forehead to fill the gap thus left. Dieffenbach's flap is triangular, while Langenbeck's is somewhat crescentic and has a pedicle turned more easily by



a *b*

Fig. 499.—Operation of Langenbeck. In *a* any unsound skin between the incisions *BAD* and *BCD* may be excised. The tip of the nose may be depressed by a deep incision along the line *BCD*. In *b* the frontal flap is shown turned into position.

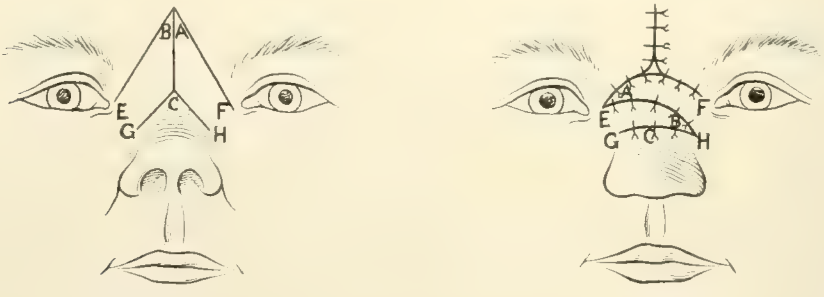


Fig. 500.—Operation of Roberts. The flap *EBCG* is turned down beneath the flap *FACH*. The part of the nose below the incisions *GCH* is thus lowered.

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* See Fig. 485, on page 701.

† "Handbuch der operativen Chirurgie," 1870, p. 324.

curving the outer incision slightly under the eyebrow. (Fig. 499.) In neither case is provision made for folding in skin to fill any gap that may exist in the mucous membrane. Cicatricial contraction is therefore certain.

OPERATION OF ROBERTS.*—Roberts has suggested a method by which flaps with their pedicles below just inside the inner canthi, and with their apices and inner borders adjoining in the middle of the forehead, may be freed and bent down so that one lies directly above the other. The tip of each flap is sutured to the pedicle of the other. The outer borders of the triangular area left exposed by the shifting of the flaps may in the upper part be drawn together by sutures. In this operation no provision is made for an inner flap. (Fig. 500.)

SECOND OPERATION OF SZYMANOWSKI.†—A rhomboidal flap is cut from each cheek. The inner sides run from the glabella downward and outward to the alæ; the outer side of each starts at the inner canthus of the eye and runs out on to the middle of the cheek. The lower borders are horizontal, and on a level with the alæ. The pedicles are adjacent to each other between the eyes. (Fig. 501.)

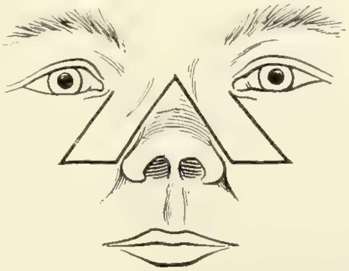

FIG. 501.—Second Operation of Szymanowski. The two flaps are brought together to fill the defect which is created when the tip of the nose is lowered.

Any cicatricial or ulcerated area on the back of the nose may be excised, and by means of a transverse cut the tip may be depressed. By drawing together the two flaps and uniting them above the depressed tip of the nose, the gap is closed. But, as no inner surface is provided, cicatricial contraction is certain.

OPERATION OF CZERWINSKI.‡—At a preliminary operation, an elliptical flap is cut from the forehead and is doubled upon itself in such a manner that the raw surface of the tip is brought against the raw surface of the base; thus a triangular flap, with an internal and an external layer of skin, is formed. And at a second operation, this flap is turned down into the gap left by freeing and depressing the lower part of the nose. If necessary, the flap may be cut obliquely from the forehead in order to gain length of tissue.

SECOND OPERATION OF ROBERTS.—Roberts has also suggested a method by which flaps of skin may be inserted between the upper portion and the tip of the nose after the latter has been lowered by a transverse cut through the depressed bridge. Flaps may be cut on each side from the fold between the nose and the cheek, and these may be folded into the gap in the nose and united by their tips in the median line. The cutaneous surfaces thus look inward. The breadth of the flaps should correspond to the height of the gap to be filled. The areas from which the flaps were removed may be closed by direct suture.

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* "Surgical Treatment of Disfigurements and Deformities of the Face," 1902.

† "Handbuch der operativen Chir.," 1870, 315.

‡ Centralblatt f. Chir., 1889, xvi., 129.

The flaps with their raw surfaces turned outward may be covered by other flaps turned down from that part of the forehead which lies between the eyebrows.

Increased Size of the Nose.

Many plastic operations intended to correct deformity or to reduce the size of parts of the nose are done subcutaneously through incisions made within the nostrils. These are not discussed here.

Increase in the size of the nose as a whole is not uncommonly due to hypertrophic acne. This condition, which is most disfiguring to the victim, may usually be satisfactorily corrected by cutting off with a knife, or scraping away with a sharp curette, the hypertrophied skin, and then covering with Thiersch grafts, if necessary, any areas too deeply denuded. The same results may be accomplished by the thermo-cautery.

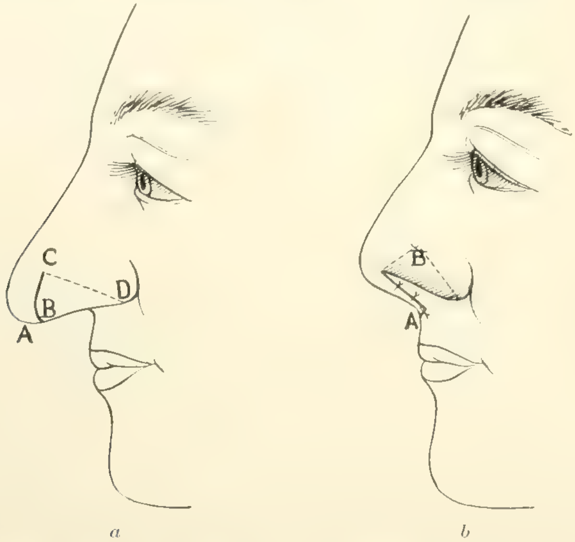

Fig. 502.—Operation of Mikulicz. The septum is divided along the line *CD* (see *a*). The sides *BCD* are folded in to form new borders of the nostrils. The tip *A* is drawn back to form a new lower border of the septum (see *b*).

Undue elongation of the nose may be corrected by the method of Joseph, who cut away, from the sides and base of the nose, a broad enough strip of skin, in the shape of an inverted V, to allow the lower portion to be raised after enough of the bony and cartilaginous framework had been removed, and after a wedge-shaped piece of the septum had been cut away.

Much more satisfactory, however, is the method of Mikulicz* who cut out a wedge-shaped piece of the lower end of the septum, thus permitting a folding backward of the elongated tip of the nose, which portion, when properly reduced in size, is used to form the new lower part of the septum. (Fig. 502.)

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* Arch. f. klin. Chir., 1884.

Absence of the Nose.

In those rare instances in which there is a complete absence of the nose at birth, the operation of Maisonneuve* is the simplest and best procedure.

Operation of Maisonneuve.—A V-shaped cut is made in the upper lip. The point of the V is exactly at the red border in the median line. The ends of the arms reach exactly to the point where the nostrils should be. Additional incisions are carried horizontally outward from the ends of the arms of the V. The tissues above this cut are drawn forward. The V-shaped piece is then bent back to form a septum. The sides of the defect left in the upper lip are drawn together. Thus nostrils, through which the child may at least breathe, are established and may be kept open by inserting rubber tubes until healing is complete.

Prosthesis.

Artificial noses have been made out of white silver, India rubber, aluminum, gutta-percha, porcelain, and paper. At best, an artificial nose is unsatisfactory; and the method of support is often a considerable problem. Certain patients can bear to have a nose supported by wires which get their bearing within the nasal fossæ or on the floor of the nose. In other cases a band, that gets its support from the occiput, has been passed over the head. The simplest and most generally satisfactory method is to have the artificial nose attached to a pair of spectacles, the necessary support being thus derived from the ears. The danger of the nose being broken is always present.

EARS.

Before considering at all the various plastic operations performed upon the external ear, we desire to call attention to the diagram of a normal ear (Fig. 503) in order to avoid confusion in the names of the various parts.

The anatomical variations, within normal limits, are greater in the external ear than in any other part of the body. The lobule may be very broad or very pointed, entirely free from the side of the neck or closely bound down to it. The helix may roll over decidedly and thus limit a rather deep fossa, or it may be so flat as to be scarcely differentiated from the fossa of the helix. Such variations are so common that it is hard to define the normal. It is only when the two ears are not symmetrical that surgical interference may be necessary.

Of more importance is the form of the anti-helix, though here again wide variations occur within normal limits. The fold along the anti-helix may be very sharp or very much rounded. The posterior arm of the anti-helix, which above divides the fossa of the anti-helix from the fossa of the helix, varies greatly in its prominence, at times being almost absent. But when there is not a clear division between the two fossae the ear is less graceful and its upper part is apt to project. Loss of a sharp division between the concha and the fossae above and behind it is clearly abnormal.

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*Bulletin de Thérapeutique, 1855, p. 559.

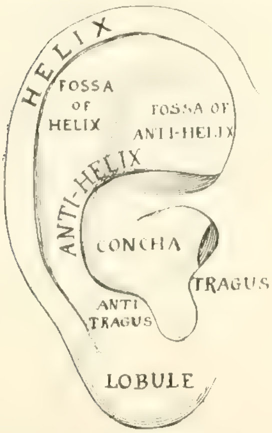


Fig. 503.—Diagram Showing the Parts of a Normal External Ear. Particular attention is directed to the anti-helix, which is usually a sharp fold below, dividing above into a sharp fold below the fossa of the anti-helix, and a much less pronounced fold above and behind it, which separates the fossa of the helix from the fossa of the anti-helix. Many malformations of the ear depend upon the shape of the anti-helix.

There are also wide variations in the manner in which the ear is attached to the head. The angle at which the ear is tilted is of relatively little importance; but the angle at which it stands off from the head is of great consequence.

The size of the ears varies greatly within normal limits, but here again asymmetry is always abnormal.

Plastic operations are undertaken:—to correct congenital or acquired defects or malformations; to correct cicatricial deformities resulting from burns, frost bites, or trauma; to restore the ear as nearly as possible to its normal shape after parts have been removed; and to correct undue prominence.

Certain general rules should be followed, as far as possible, in operations on the ear. Incisions, for example, should, if possible, be confined to the posterior surface. Accurate apposition of cartilage to cartilage and of skin to skin is also very important. The attempt should never be made, if it can possibly be avoided, to hold the ear or any portion of it in a new position against the natural spring of the cartilage. As the ear is peculiarly liable to keloid formation, it is very important to secure healing by first intention and to avoid tension upon or irritation of any scars.

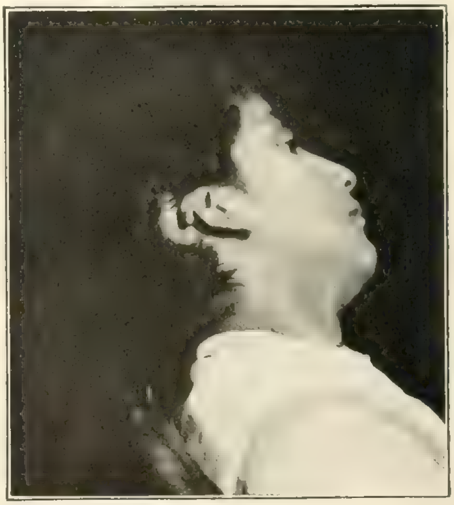


Fig. 504.—Malformation of the Ear Due to Irregular Union of the Cartilages.

Congenital Anomalies of the External Ear.—Among the congenital anomalies of the external ear there are many varieties. In some instances, the entire ear is lacking; in others, portions are lacking; in still others, there is a congenital anomaly of form due to a misplacement of the cartilages upon each other. (Fig. 504.) In cases in which any large part of the external ear is missing, plastic operations should be undertaken only after most careful consideration. It is a matter of such extreme difficulty to build up an external ear which shall maintain its shape for any length of time that better results are usually to be obtained by using some prosthetic apparatus. Attempts have nevertheless been made to form an ear by utilizing the skin from over the mastoid region, a double flap being employed. Such an operation has been described by Szymanowski, who made the external flap by a semilunar incision posterior to the meatus. This incision is incomplete behind in order that a crescentic piece, convex anteriorly and of the same size as the first flap, may be left attached to it to be folded in to form an inner flap. At best such an ear would be a shapeless projection of flabby skin.

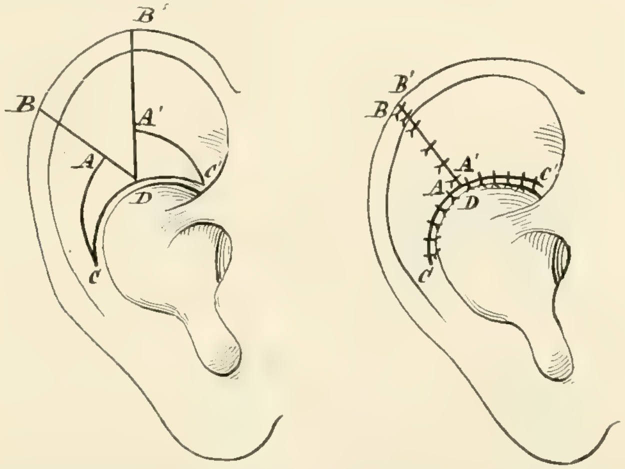


FIG. 505.—Operation for the Removal of a Wedge-shaped Portion of the Upper Ear. (After Cheyne and Burghard.) The distance from *A'* to *B'* should equal the distance from *A* to *B*. In this manner any inequality in the lengths of the sides of the wedge as originally cut may be disregarded.

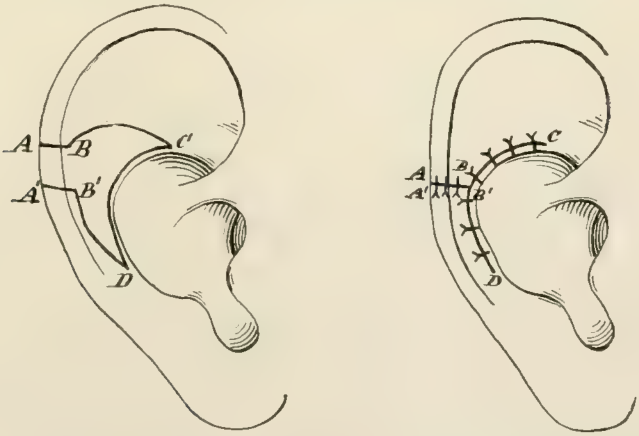


FIG. 506.—Operation of Parkhill. The same rule holds as in the preceding operation.

Attempts have also been made to form a new ear by transferring skin first from the abdomen to the arm, and then from the latter to the head.

In some of the less serious defects it may be possible to make the lower part of the ear relatively normal and trust to concealing beneath the hair the absence of the upper part.

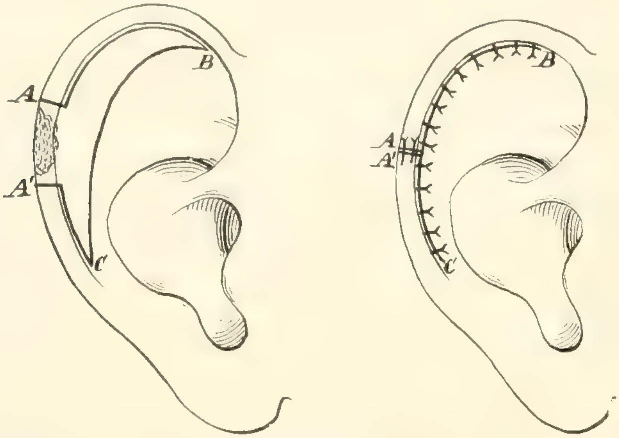


FIG. 507.—Operation of Gersuny. Method to be followed where the defect is located in the upper part of the helix.

In cases in which the cartilages are misplaced, one upon another, very marked benefit can usually be derived from a carefully planned plastic operation. It is important always in such cases to plan the flaps in such a way that every particle of skin may be saved, as usually in addition to the defect of form there is a defect in size. In all such cases the elasticity of the cartilages is to be carefully taken into consideration in planning the operation.

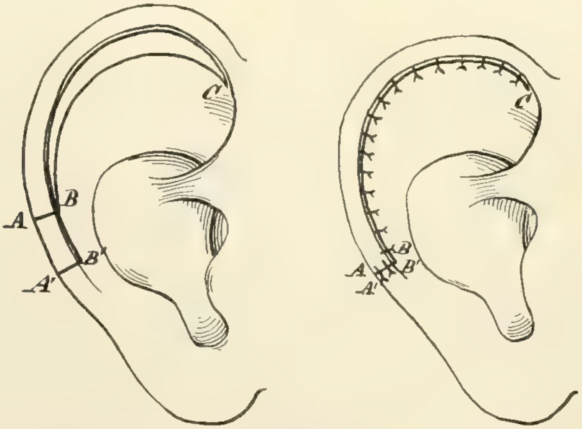


FIG. 508.—Operation of Gersuny. Method to be followed where the defect is located in the lower part of the helix.

ACQUIRED DEFORMITIES OF THE EXTERNAL EAR.—One of the most common acquired deformities is a binding down of the lobule to the side of the neck by cicatricial bands, usually the result of severe burns. This may be easily corrected by cutting across or excising any such bands and uniting the edges of the skin on each side separately. Though the shape of the lobule differs greatly in different individuals it is essential that the two sides should, if possible, be symmetrical. It is important, also, that the incisions be made low enough to include sufficient tissue to form a lobule of proper size, and with the resulting scar upon its posterior surface, where it may be inconspicuous. The removal from the neck of the extra tissue necessary to accomplish this does not materially add to the visible scar.

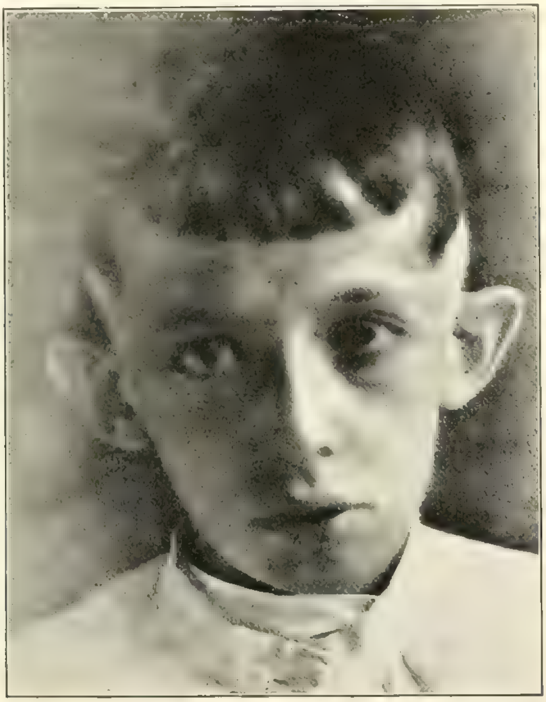


Fig. 509.—Outstanding Ears. The deformity is due to the position of the ears as a whole upon the head. The angle at the anti-helix is normal.

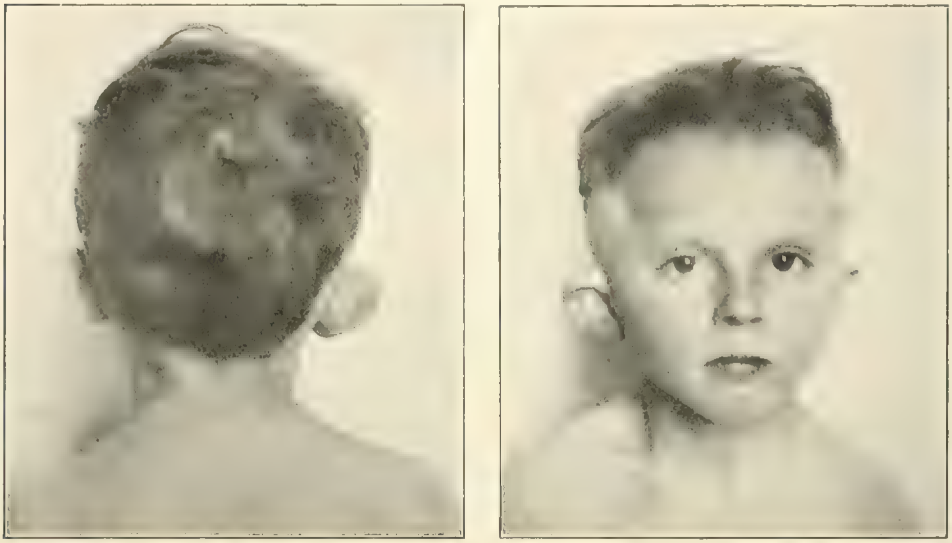
An absence or defect of the lobule may be corrected in a similar manner by taking a flap of skin and underlying tissues from the neck. It must be remembered, however, that the fat in such a flap is largely absorbed and that the skin shrinks decidedly as soon as it is transferred to its new position and so in part deprived of its nutrition. It is, furthermore, a very difficult matter to form a new lobule which shall appear to spring normally from the ear rather than from the neck.

Minor defects of the lobule which are quite common may be corrected by direct union of the sides of the gap.

Under some circumstances the injection of paraffin into the lobule may be of use.

Cicatricial contractions of other parts of the external ear are often most difficult to correct. Unless they are situated in places where it is easy to introduce skin flaps from the cheek or from other neighboring parts it is very frequently found that cicatrices in the upper part of the ear which draw it downward or forward involve more or less of the cartilage. In the correction of such deformities no general rules can be laid down because no two cases are alike. It may often be possible, however, to free the skin and slide it upon the underlying cartilage unless the surface is too rough and irregular.

In cases in which a part of the upper ear is lost several methods have been devised, the object of which is to maintain as far as possible the general form of the ear, and at the same time prevent the union of the sides of the defect from drawing the remaining parts out of their proper positions.



a *b*

Fig. 510.—Outstanding Ear. The deformity is due chiefly to the position of the ear as a whole—in small part only to the loss of the angle at the anti-helix. *a*, Rear view; *b*, front view.

Operation of Cheyne and Burghard.—Cheyne and Burghard* describe a method by which a crescentic piece, immediately above the anti-helix, may be removed in order to allow approximation of the sides of a wedge-shaped gap in the upper part of the ear. (Fig. 505.) The prominent edge of the anti-helix is left intact. The posterior upper arm of the anti-helix is disregarded.

Operation of Parkhill.—Roberts† describes a method that was devised by Parkhill, and that is adapted to reducing the size of the ear or to closing a defect in the helix at its posterior part. (Fig. 506.) In all essentials the operation is similar to the one just described, except that the crescentic piece is excised from an area behind rather than above the anti-helix.

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* Vol. v., p. 183.

† "Deformities of the Face," page 57.

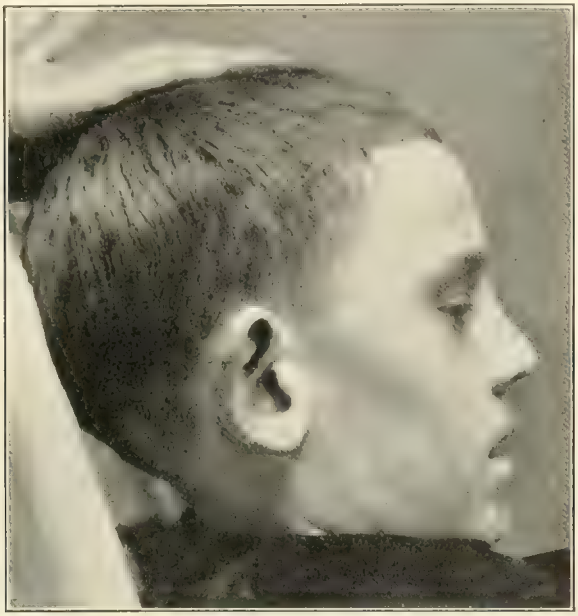

Fig. 511.—Prominent Ear. Deformity is due to loss of normal angle at the anti-helix. (Compare Fig. 510.)

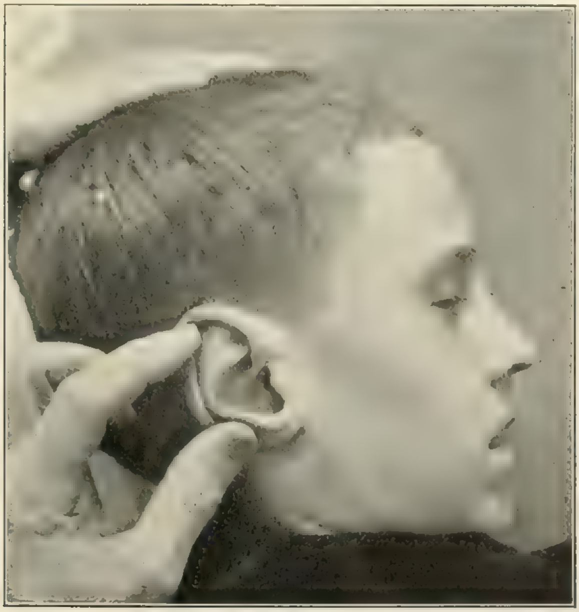

Fig. 512.—Prominent Ear. The deformity due to loss of normal angle at the anti-helix is done away with by restoring the angle. (Same person as in Fig. 511.)

Operation of Gersuny.*—Gersuny, instead of excising a crescentic area above the anti-helix, has taken out a crescentic piece from the outer part of the fossa helicis, just inside the helix. (Fig. 507.) In this manner the scar is left in a less conspicuous position, just under the fold of the helix; and no strain whatever, or change in relation of the more central parts of the ear, is caused. The operation is admirably adapted to those cases in which a part of the helix is lost, but in which there has been no loss in the more central part of the ear toward the anti-helix. The upper outer border of the excised crescent must reach along the edge of the helix as far as the point where it is attached to the head. The width of the crescentic piece of pinna removed should be nearly two-thirds the length of the gap to be closed.

Almost precisely the same procedure may be followed when the defect in the helix is low down. (Fig. 508.) The crescentic piece need not be excised from an area adjacent to the defect, but it should, by preference, be taken from the most prominent and curving part of the ear, where the removal of a relatively small piece will not materially diminish the size of the circle which the freed helix must surround. The risk here lies in the impaired nutrition of the long flap of the helix.

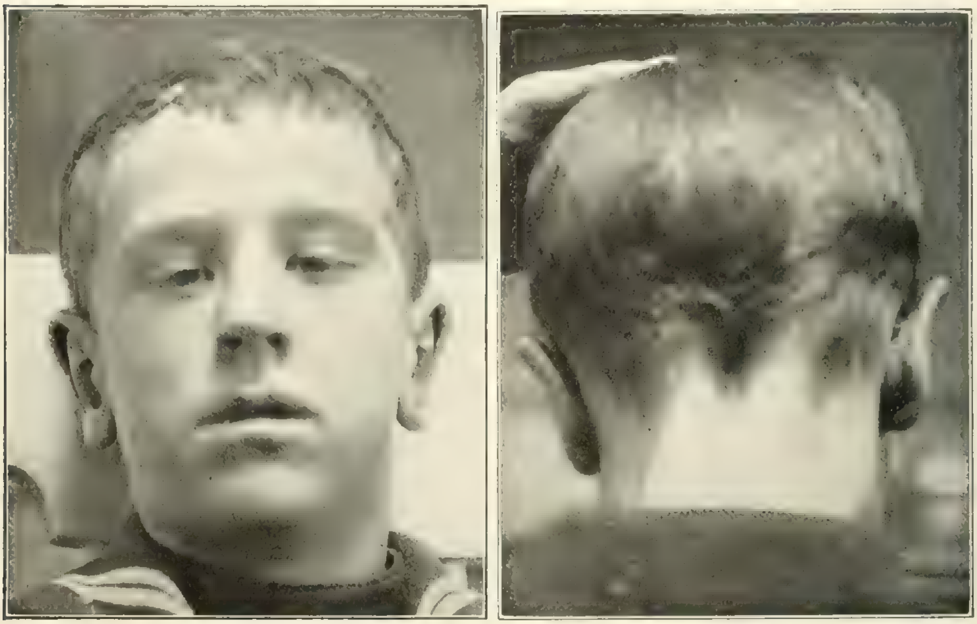

Fig. 513. Fig. 514.

Figs. 513 and 514.—Result of Operation to Restore the Angle at the Anti-helix. (Same person as in Figs. 511 and 512.) Fig. 513, front view; Fig. 514, rear view.

Any of these operations may, of course, be performed in cases in which it is desired simply to reduce the size of the ear.

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* Wiener med. Wochenschrift, 1903, No. 48.

Abnormally Prominent Ears may be divided into two groups: in the first, the ear itself is of normal shape, but is attached to the head in an abnormal position. (Figs. 509 and 510.) In the second group, the prominence is due to an abnormality in the ear itself. (Fig. 511.)

It should be borne in mind constantly that *the shape of the ear depends upon the shape of the cartilage, and the shape of the cartilage depends chiefly upon its area.*

If it is necessary to bring the ear as a whole back against the head, crescentic pieces of skin may be removed from the upper part of the mastoid process and from an exactly corresponding area on the posterior surface of the ear. It is essential that all tissues be removed down to the periosteum of the skull and down to the cartilage of the ear. It is usually wise to go further and shave off some of the cartilage without actually perforating it, in order that the force of the spring in the cartilage may be diminished. Cartilage should be united to periosteum. If any tissues intervene, the spring of the cartilage will cause stretching of the scar; and the deformity may then be reproduced. If so, in addition to the prominence, the appearance of the ears from behind will be very objectionable. With the excision of the pieces of skin the natural depth of the

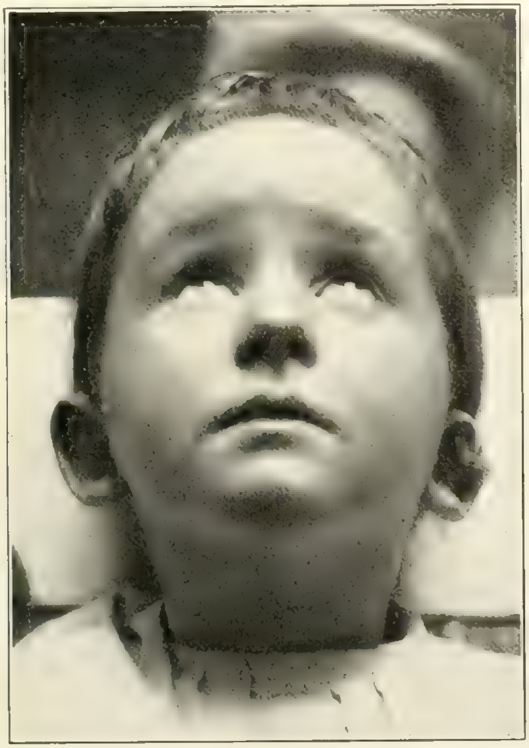

Fig. 515.—Prominent and Misshapen Ears. That on the patient's right side is unduly prominent, while that on the left is both prominent and misshapen. No angle at anti-helix on either side.

fold between the ear and the side of the head is much diminished. If the resulting scar becomes stretched out, the ears, as seen from behind, suggest those of a bull-dog.

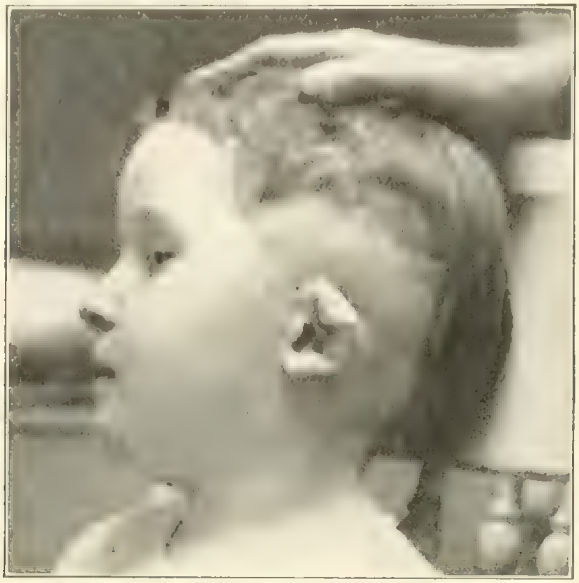

Fig. 516.

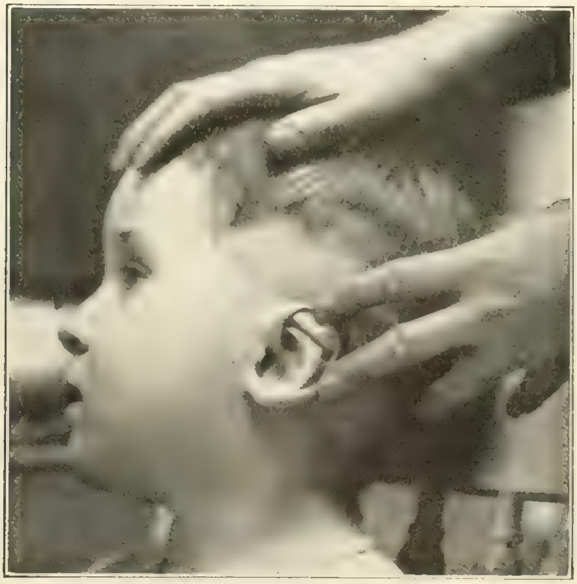

Fig. 517.

Figs. 516 and 517.—Side Views of the Same Person's Left Ear. (Compare Fig. 515.) Fig. 516, malformed left ear; no angle at anti-helix; redundant cartilage in upper part of ear. Fig. 517, angle at anti-helix of the same ear restored; redundant cartilage brought into view by restoring the normal position of the parts.

In the second group of cases, the upper or posterior parts of the ear, or both, stand out abnormally, owing to an insufficient angle at the anti-helix, between the concha and the fossæ above and behind it. Such a deformity may vary in degree up to a complete absence of the anti-helix, in which case the concha seems to include the whole upper part of the ear. (Fig. 511.) This type of deformity may, of course, be corrected by uniting the ear to the side of the head, exactly as has already been described. It is more rational, however, to correct the deformity by changing the shape of the cartilage. It is possible to determine the exact line along which the shape of the cartilage needs to be changed, by pressing back the ear with the fingers. (Fig. 512.) Then, by excising a piece of skin from the posterior surface along this line and cutting out a strip of cartilage, the ear will assume a normal shape. In doing this, it is important to avoid perforating the skin of the anterior surface, unless under exceptional circumstances it may seem wise to excise a segment including the entire thickness of the ear.

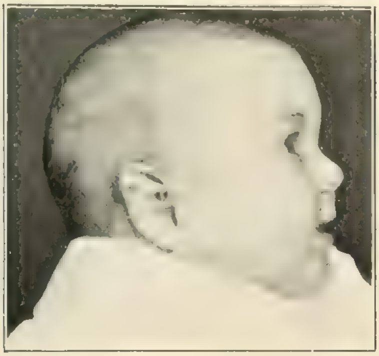

FIG. 518.

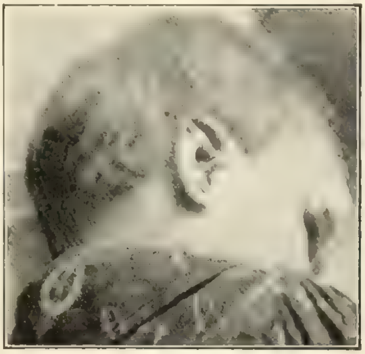

FIG. 519.

FIG. 518.—Malformation of Upper Part of Ear Due to Abnormal Prominence and Direction of the Posterior Arm of the Anti-helix.

FIG. 519.—Malformation of the Posterior Arm of Anti-helix. In both this and the preceding persons the malformation is due to redundant area of cartilage.

Usually, however, any redundancy of the anterior skin soon disappears. (Figs. 513 and 514.)

In some instances the prominence of the ear is due to the large size of the concha which, in spite of a normal angle at the anti-helix, swings far enough forward to make prominent the parts behind and above it.

The shape of the piece of cartilage to be removed varies in each individual case. At each end it should always taper to a point. When the cartilage is thick enough to make any difference, the piece removed should be wedge-shaped, wider on the posterior than on the anterior surface. The width of the strip, its direction, and its shape must vary with circumstances. Most important of all is that the two ears should be symmetrical. (Fig. 515.)

The dependence of the shape of the ear upon the area of the cartilages is well shown in Figs. 516 and 517. In such a case excision of a certain amount of cartilage is absolutely necessary in case the ear is to be restored to its normal shape. In such a condition the wearing of caps to hold the ear back would be absolutely useless. In many cases, however, in which the cartilage springs into either a normal or a completely abnormal position upon the application of slight force, simply holding it in normal position may easily lead to a complete cure without operation.

A comparison of Figs. 516 and 517 with those of congenital malformation of the anti-helix (Figs. 518 and 519) is interesting and suggestive as regards the importance of the area of cartilage in causing the malformation.

Artificial Ears.—Artificial ears, usually made of papier-maché, may be attached easily by means of springs encircling the head and concealed by the hair. They must of course be modelled to correspond exactly to the ear of the opposite side. When the defect is great, the appearance of an artificial ear is usually better than that of anything which can be constructed by plastic operations. The chief and unsurmountable difficulty with an artificial ear is its necessarily constant color.

PART XV.

ORTHOPEDIC SURGERY.

CONGENITAL DISLOCATIONS.

By CHARLES F. PAINTER, M.D., Boston, Mass.

Of the congenital deformities to which the human body is subject, dislocations of the various joints represent a considerable portion. Some of these are not true dislocations, but are described as such because one bone which normally participates in the construction of an articulation is out of its customary relations in consequence of the absence, in whole or in part, of its companion bone. In this way when, for example, the radius is missing, we may have a congenital luxation of the carpus, and when the fibula or tibia is absent we may have a congenital luxation of the tarsus. This is an entirely different condition from that which obtains when, through a defect in the shape of the acetabulum or of the contour of the femoral head, these two bones are not kept in normal relations to each other.

The causes for these congenital defects are scarcely better understood to-day than they were ten years ago (1898), when Kirmisson, after devoting nine years to their study, ventured to publish his "Traité des Maladies Chirurgicales d'Origine Congénitale."

These dislocations, such as that of the carpus or tarsus, associated with a congenital absence of the radius or the fibula, are obviously different in their causation from those of the hip. In the former there is undoubtedly some embryological defect whereby an entire member has been left out. In the latter there is much less evidence of a lack in development, the conspicuous feature brought out by a study of the cases being that the deformity seems to be caused by a faulty position of the fœtus in utero.

Many factors may enter into the etiology of congenital dislocations. Developmental peculiarities of various kinds, abnormalities of position of the fœtus, and changes in the amount of amniotic fluid and therefore of the pressure upon the fœtus from the walls of the uterine cavity, are the chief influences which seem to be concerned in the production of these deformities. An appreciation of the fact that such factors as these are concerned in the establishment of the conditions under consideration should have an influence in determining the character of the treatment undertaken. The influences which determine growth and development are not known in their entirety. The arrangement of the cells composing those parts of the embryo which are to enter into the formation of a given bone or joint may be an essential feature of the normal growth of that part. It is obvious that if such arrangement is an essential in the matter of growth, no human power can effect a rearrangement of these cells. It is even more inconceivable that any peculiarities of development, which are dependent upon the absence of cells or groups of cells from a given bone or joint, should be capable of correction by human agency. After the termination of uterine life there may be extra-uterine conditions which are influential in determining the increase of deformities already begun which were not dependent upon any primary structural defects in the embryo. It seems more than likely that an approximation of the constituent parts of a joint, after the manner that Nature has employed, represents an essential factor in the normal growth and development of that joint. There is abundant evidence that the deprivation of any part of the body of its capacity for normal function impairs the growth of that part; and if that can be true, as it is, at a period of life when growth has ceased, except in so far as a replacement of the wear and tear of tissue is concerned, it must certainly be all the more true of those periods of life when there is the greatest cellular activity and the greatest evidence of tissue building and growth. Where infantile paralysis or some inflammatory condition causing an ankylosis of large joints has been present, there is a very noticeable interference with the growth of the limb in length. The failure to increase in length is indicative of a diminution of the nutritive processes in the limb very largely dependent upon the impairment of function. Abundant evidence of this influence could be adduced were further proof necessary.

When the bones of limbs thus put out of commission through paralysis or ankylosis are studied by means of the radiograph, it is at once apparent that there is an atrophy of structure as well as an atrophy of size. When such an articulation as the hip joint is studied under such conditions as have been described above, it is found that this structural atrophy is not confined to the femur, but is apparent in the innominate bone as well. Thus it can readily be understood that impairment of function at a given joint, whether brought about by inflammation or paralysis—two causes which must operate to a certain extent in different ways—results in structural changes in the respective articulation. If such changes as are evident under these circumstances can take place for this cause, it seems reasonable to explain the changes which are so evident in many of the congenital misplacements, luxations, and dislocations on the ground that they are structural adaptations to the anatomic disarrangement. We are no nearer an explanation of the prime causes of the dislocations than we were before, perhaps; but we are in a position to anticipate the results of various forms of treatment more intelligently than if we regard the congenital dislocation of any joint merely as an anatomic condition, which only requires the proper manipulative dexterity to insure a restoration to the normal both anatomically and functionally. It has seemed to the writer that, in much of the discussion of congenital dislocations, particularly in that which has been written concerning congenital dislocation of the hip, this point of view had been lost, and that the ideal result which the surgeon had been holding up as his goal was that of the traumatic dislocation which was capable of manipulative reduction. In consequence of the pursuit of such a false ideal much unprofitable discussion and unfruitful investigation has been indulged in by many enthusiasts whose zeal has prompted injudicious endeavor.

Hoffa,* in discussing congenital deformities, under which heading are included all the dislocations, makes two main divisions.

The first includes the primary or idiopathic deformities, of which congenital club-foot, club-hand, and congenital scoliosis are examples. In this class he calls attention to the atavistic character of the deformities, pointing to hereditary influences.

In his second class he includes those deformities which have resulted from abnormal conditions in utero, the result of faulty posture, or abnormalities in the amount or distribution of the amniotic fluid. Among these are congenital dislocations of the hip, intra-uterine amputation of limbs, and congenital absence of individual bones or parts of bones. By such abnormalities of position and variation from the normal conditions of intra-uterine pressure, embryonic differentiation of tissue may be materially influenced.

Tubby † discusses three theories of the origin of congenital deformities, particularly in their bearing upon congenital dislocation of the hip.

The first theory is that at birth there has been some mechanical cause for the deformity connected with the difficulties of exit from the uterine cavity and vagina.

The second theory concerns itself with the pathological causes for congenital deformity, which he considers under three heads, viz.: (1) Muscular contracture due to lesions of the central nervous system; (2) Paralysis of intrinsic muscles, as, for example, those about the trochanter in cases of congenital hip dislocations; (3) Morbid conditions of cartilage and ligament.

The third theory relates to developmental defects in the embryo, and it is this theory which receives Tubby's support.

Riedinger ‡ divides congenital deformities into (*a*) those produced by intra-uterine contractures and (*b*) Belastungsdeformitäten. He points to the fact that the position assumed by the fœtus in utero and the development of the amniotic sac and the amount of its fluid content are factors in the production of deformity. He also explains some deformities on the ground of defects in the development of the skeleton and cites fœtal disease as an occasional cause of intra-uterine deformity. Intra-uterine fœtal hæmorrhage may cause muscular degenerations which occasion contracture of fœtal muscle and give rise to dislocation and other deformities.

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* Hoffa: "Lehrbuch der orth. Chir.," 1902, p. 10.

† Tubby: "A Treatise on Orthopædic Surgery," p. 522.

‡ Riedinger: Joachimsthal's "Handbuch der orth. Chir.," p. 33.

Stimson,[*] after discussing the earlier history of the study of congenital dislocations, takes up the various theories which have been advanced to explain congenital dislocations in general and particularly in the case of congenital dislocation at the hip joint. He is an advocate of the theory of developmental deficiency, and believes this is particularly true and easy of recognition in the case of congenital hip displacements. He cites an instance where intra-uterine hydrops articuli had been present and had so distended the joint capsule that a dislocation resulted. He believes that trauma, abnormal position in utero, and paralysis may account for some of the cases. Coexistence of two or more congenital defects or dislocations, a manifest tendency in some deformities to be transmitted from generation to generation, and the frequency of bilateral dislocations he regards as strong proof of the theory of arrested development.

Young [†] discusses briefly four theories of the cause of congenital deformities, including congenital dislocations, viz.:

1. Heredity.
2. Mechanical (intra-uterine pressure and trauma).
3. Prenatal disease.
4. Arrest or defect of development.

He is inclined to favor the fourth of these theories as giving the most plausible explanation of most of the deformities of this class.

Kirmisson in his text-book, already quoted, devotes his entire attention to the exposition of his theories of the origin of congenital defects and dislocations. His studies are based largely upon embryological investigation, and therefore relate chiefly to the theories which have already been cited bearing upon developmental defects, some of which are inherent in the embryo and for which there is no other explanation than that they are idiopathic, and others of which are influenced, to some extent at least, by abnormalities of intra-uterine pressure. This abnormal pressure may cause atrophy only, or if kept up long enough, or if severe enough, may lead to a total inhibition of embryonic development. On this theory are explained conditions of deformity which vary all the way from only a slight departure from the normal anatomical relation to a complete absence of a member or some essential osseous component of that member. Such theories are competent to explain some of the dislocations which are due to the absense of bones or portions of bones entering into the composition of a given joint.

The consensus of opinion of writers best qualified to express an opinion upon the causes of congenital dislocation would seem to favor the theory of interference with development in the embryonic or fœtal state. There seems to be but little actual proof to support such theories as that of fœtal disease or paralysis of groups of muscles during fœtal life. Positive proof in relation to such matters is at best sufficiently difficult to secure. The effects of constriction, compression, and distention of various kinds upon growing bones are known; and the possibility of the existence of such forces during fœtal life has been abundantly demonstrated. It is, therefore, easy to understand how, under the exercise of force of this kind during a period of life when tissues are most susceptible of modification, disruption of their normal relations may easily take place, giving rise to dislocations. It is, furthermore, not a difficult matter to understand how during the earlier months of extra-uterine life the inability to function properly would aggravate conditions already existing, and that such aggravation would naturally be all the more pronounced because the activity of the tissue-building processes is only slightly less during the early weeks of extra-uterine life than it was before birth. The influence of faulty positions in utero, upon the production of some of the most common dislocations, seems a very easy thing to comprehend. That faulty positions do occur at this time has been not infrequently observed.

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[*] Stimson: "Fractures and Dislocations," 1900, p. 463.

[†] Young: "Manual and Atlas of Orthopædic Surgery," 1905, p. 838.

Having discussed at some length the reasons for the existence of congenital dislocations, it will now be well to consider the individual dislocations in order.

Trunk.—In the trunk there are many congenital defects, such as numerical variations in the number of vertebræ, there being in some cases too many cervical and too few thoracic, or too many thoracic and too few lumbar. Ribs may be attached to the lower cervical vertebræ and not to the lower thoracic, but there are no luxations of the vertebræ which are of congenital origin. In the process of development of the bony skeleton the scapulæ are situated higher upon the vertebral column than where they ultimately rest, and the innominate bones are situated higher up than they are found in extra-uterine life. In the process of development they both descend. It occasionally happens that the innominates do not descend equally on the two sides, and we then have, according to Böhm and others, a cause for congenital scolioses. Whether a similar irregularity in the scapulæ accounts for the abnormalities in the height of these bones, which Sprengel* first described, has not as yet been made clear.

Congenital Elevation of the Scapula.—In 1891 Sprengel described four cases of this deformity, drawing the attention of the profession to a condition which must have existed but which had been overlooked or regarded as a part of some other deformity, such as scoliosis or torticollis, both of which are not infrequently associated with it. Since Sprengel's first report a great many different observers have recorded similar cases, so that now the deformity is a well-recognized clinical entity.

It gives rise to no particular symptoms of a subjective character and may not be recognized for several years after birth or until the deformity is sufficiently pronounced to attract attention. There seem to be two distinct types of elevation of the scapula. In one there is a bridge of bone connecting the superior angle of the scapula with the spinous process of some one of the neighboring cervical vertebræ. There is usually a false joint at either end of this osseous bridge, thus permitting a certain amount of motion between the upper part of the scapula and the vertebral column. In one such case seen by the writer this bridge was about three-fourths of an inch in length. This condition is sometimes associated with an extra rib in the cervical region. Kirmisson has described other congenital deformities associated with it. The more common type of congenital scapular elevation is not associated with osseous bridges connecting these points, but the scapula seems to be held in its elevated position by the shortening of muscles attached to the body of the scapula. In Figs. 520 and 521 is shown a patient with a bony bridge joining the scapula to the spine. The deformity in this class of case is usually greater than in the other. Fig. 522 illustrates the usual type of scapular elevation. Functionally there may be considerable disability connected with the deformity, especially in the cases where there has been an osseous connection between the scapula and the spine. In the writer's case, lateral and forward elevation of the arm was restricted fully one-half that of the normal arc. Very little motion is permitted independently of the movement of the scapula. There is no paralysis of the muscles about the

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* Sprengel: Archiv für klin. Chirurgie, xlii., 3 Heft, p. 345.

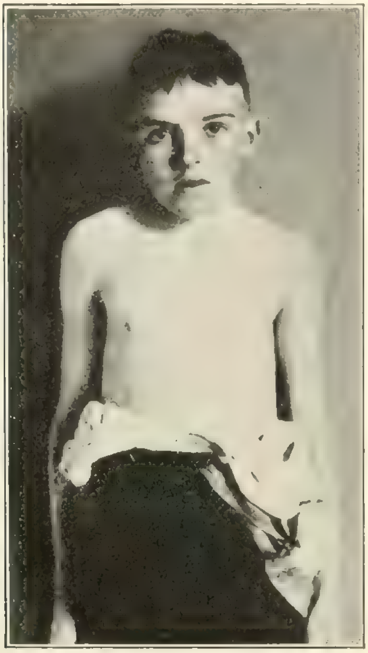

FIG. 520.

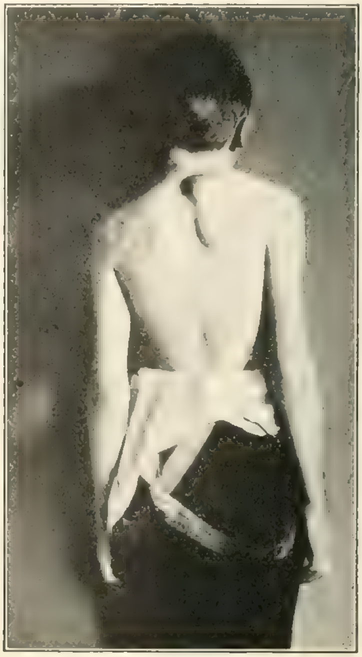

FIG. 521.

FIG. 520.—Front View of Case of Congenital Elevation of Right Scapula. Observe the height of right shoulder and the drawing down of the head toward this shoulder. (Original.)

FIG. 521.—Back View of Fig. 520. Note the height of the right scapula and right shoulder, also the prominence of the superior angle of the right scapula. The seventh cervical vertebra was joined to the superior angle of the scapula by a bony bridge. (Original.)

shoulder, but the position of the scapula is such that these muscles cannot act upon that bone in a normal manner; nor can they secure from their attachment to it the proper anchorage to permit of their acting at a distance upon the bones into which they are inserted. Upon examination, the inferior angles of the scapula are observed to be upon different levels. The vertebral border of the elevated scapula is farther removed from the spinous processes than that of the normal side; it is also much more prominent than normal, seeming to have been rotated upon a vertical axis, so that the axillary border stands in closer to the ribs, and the vertebral border stands away from the chest wall. The shoulder is generally higher on this side and the arm seems to be carried forward. The angle which the neck makes with the shoulders is changed and the normal graceful curve is lost on the elevated side. The spine is pulled over into a position of scoliosis in some cases, with compensatory curves both above and below, and occasionally there is a permanent torticollis produced in the same manner. The *x*-ray shows a diminution in size of the entire scapula as well as a difference in its position. The treatment of this condition cannot generally be commenced before the child has reached the age of four or five years, or is even older. It is generally about this time that parents come to the conclusion that there is some trouble demanding attention, and that the deformity of which they may possibly have been cognizant for a considerable period of time is becoming gradually worse, rather than being outgrown as they had persisted in hoping. Even had the deformity been recognized at a very early period, it is probable that but little could have been done by mechanical or physical means to correct it. This would, of course, be true of the type in which there was an associated bony bridge. A very considerable improvement in the appearance of the back and of the relative positions of the scapulæ can be brought about by surgical measures, as is shown in Figs. 523 and 524. The line of incision over the back of the scapula indicates the best way to reach all the muscles whose attachment it is necessary to divide in order to pull the scapula down. All the muscles attached to the vertebral border and the spine of the scapula must be severed and allowed to re-attach themselves after the bone has been

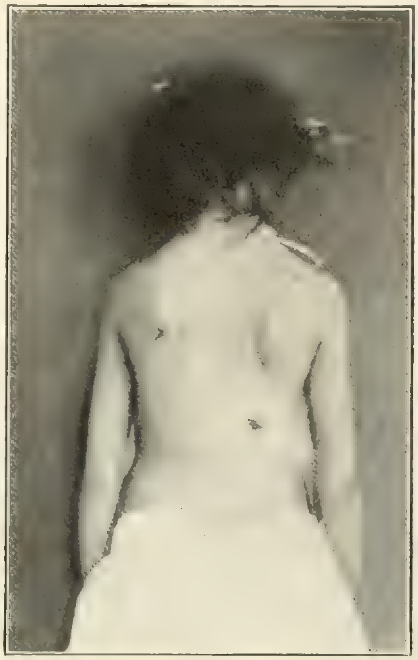

FIG. 522.—Before Operation. Observe the difference in height of the scapular angles and the greater distance of the vertebral border of the left scapula from the median line. (Original.)

drawn down as far as possible. The employment of plaster fixation or prolonged retention in splints is not necessary after operation; and the patient should be encouraged to practise exercises, and should have passive manipulations and massage as early as the third or fourth week after operation. In those cases where there is a rudimentary rib connecting the cervical spine with the superior scapular angle it is, of course, necessary to resect this bridge and at the same time to detach the muscles as in the other type of deformity. A restitution to the normal is not possible, but a very considerable cosmetic benefit may be secured, and a moderate improvement in functioning capacity may be looked for in those cases in which the muscles have been unable to work to advantage.

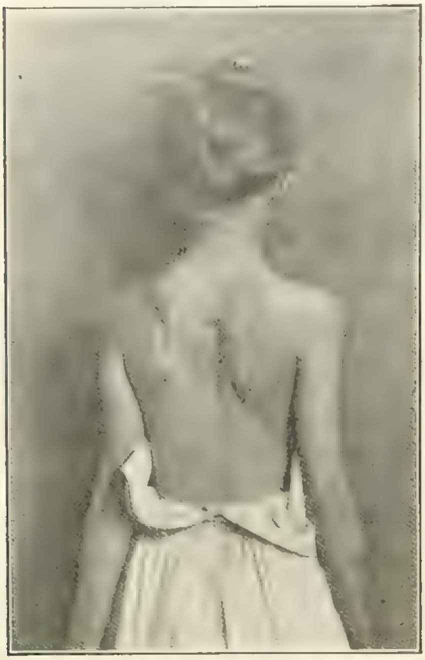

FIG. 523.

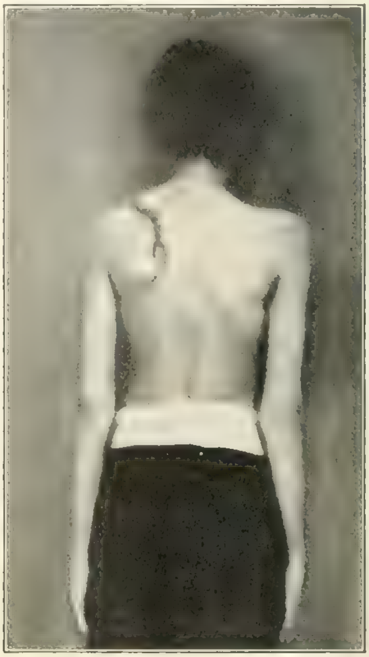

FIG. 524.

FIG. 523.—Illustrates the Line of Incision and the Result of Operation to Pull the Left Scapula Down into a More Nearly Normal Relation to the Right Scapula. This is an illustration of the case shown in Fig. 522, after operation. (Original.)

FIG. 524.—After Operation. Photograph taken before the operation has been lost, but the deformity was much the same as shown in Fig. 522. This was an older boy and the result was not quite as good as in the case shown in Fig. 522. (Original.)

CONGENITAL DISLOCATION OF THE SHOULDER, AND OBSTETRICAL PARALYSIS.—It is generally admitted that congenital dislocations of the shoulder are of extreme rarity. Many which have been described as such were unquestionably the result of traumatisms at birth, with or without paralytic complications. Scudder * reported two cases occurring in the same family. These were subspinous dislocations. Kirmisson, although admitting the possibility of such

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* Scudder: Archives of Pediatrics, 1890, vii., p. 260.

dislocations, believes them to be very unusual and has seen only one, and that a subacromial type. He recognizes as possibilities the subcoracoid, a backward subspinous, and a forward or subacromial. A few of these have been described, chiefly by anatomists.

Associated with the more severe grades of obstetrical paralysis there are very frequent instances of luxation of the head of the humerus, more or less complete, amounting sometimes to a true dislocation of the head of the bone from the glenoid cavity. It has been repeatedly observed in paralytic conditions in the lower extremity that dislocation can result from paralysis of the muscles whose normal function is to keep the capsule of a joint firm, and thereby hold the head of the bone so firmly in its socket that the performance of the customary functions of that articulation will not force it out of place. Anterior poliomyelitis has frequently caused so great a weakening of the muscles about the hip joint, that dislocation has taken place there. It seems very reasonable, therefore, that a mild luxation of the humeral head brought about by paralysis of certain groups of muscles about the capsule of the shoulder should eventuate in a true dislocation. This outcome is undoubtedly favored by a lack of normal development of the glenoid cavity and of the humeral head, as the child grows up suffering from a lack of functioning capacity in the shoulder joint. Pressure upon, or stretching of, the large roots of the brachial plexus during delivery is responsible for the paralysis which results in a luxation of the shoulder joint. This is usually noticed very early in infancy; because the paralysis extends to the muscles of the arm and forearm; and loss in power of these muscles makes itself evident even in an infant, in awkward positions of the arm as well as in disinclination to use it even in the aimless manner so common to babies. The arm is held more or less limp at the side, with the thumb strongly rotated to the back, but lying close to the thigh. The contour of the shoulder becomes changed, owing to atrophy of the muscles that make up the

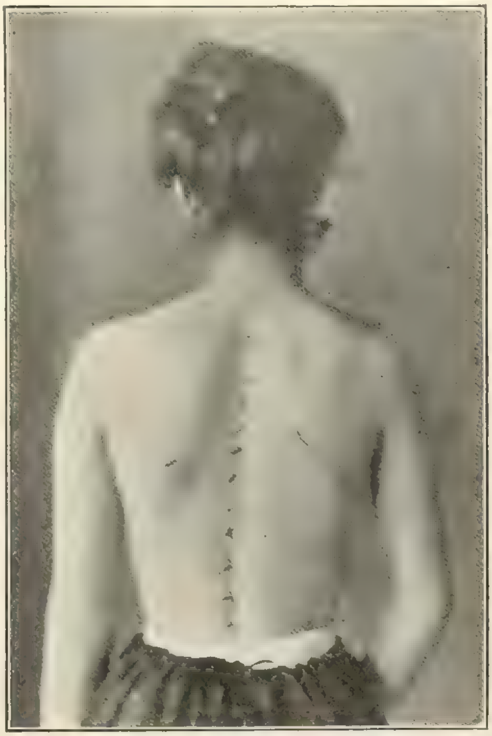

FIG. 525.— Observe the position in which the right arm is held, the low right shoulder, the atrophy of the scapular and shoulder muscles, slightly higher level upon which the inferior scapular angle lies, as well as the deviation of the spinal processes toward the left. (Original.)

roundness of the shoulder; this is due partly to actual paralysis and partly to disuse. The elbow is usually flexed and stands away from the side at a much wider angle than does the elbow of the unaffected arm, as is shown in Fig. 525. Functionally the arm is considerably impaired, and the ability to raise it from the side or to flex it forward is often very considerably restricted. This inability is due more to a loss of power in the muscles that permit of such movements, than it is to the luxation of the humeral head, but the latter is an element in the incapacity. The deformity which is secondary to this condition is scoliosis, which was well shown in the illustration on page 737. Atrophy of the soft parts, which is a conspicuous feature of this luxation, is accompanied by structural atrophy of the humerus, as is seen in the *x*-ray, Fig. 526.

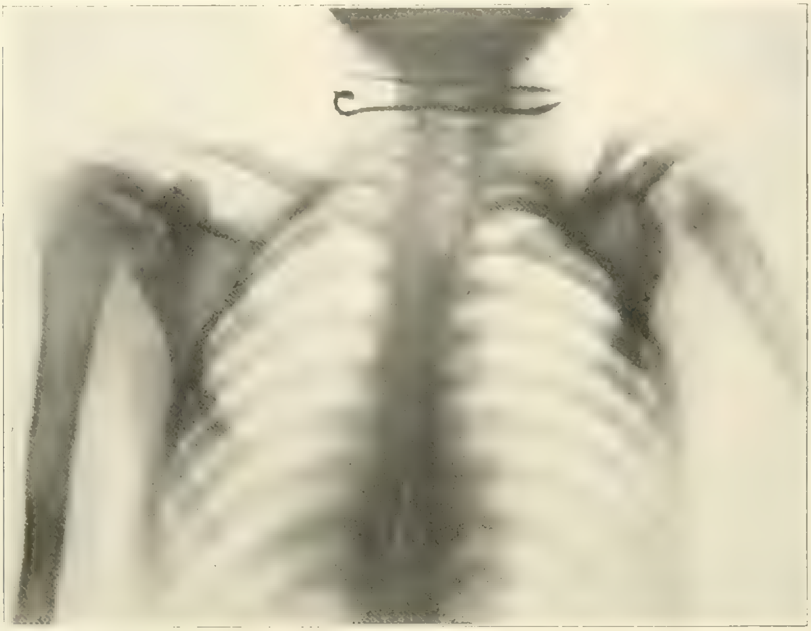

FIG. 526.—This is an *x*-ray of the Case Shown in Fig. 525. Note the structural atrophy of the right humerus, the change in the position of the scapula, the distortion of the clavicle, and the relation of the head of the humerus to the glenoid cavity on the two sides. (Original.)

The treatment of luxations of the shoulder, whether caused by lack of development during uterine life, or due to a paralysis of the intrinsic muscles of the shoulder, is necessarily unsatisfactory. The operative replacements of the congenitally defective heads into congenitally shallow glenoids have been almost uniformly unsuccessful. They do not remain when put back, because there is not enough to hold them when they are reduced. If ankylosis is produced they are little, if any, better off.

It would seem that an arthroplasty might yield good results in the shoulder; but, at best, a very unstable joint must be looked for.

In the type of luxation caused by obstetrical palsy much can be done in many cases by the early institution of massage, and passive and active manipulation. In this way the strength of the arm is conserved, and the contractures which inevitably follow disuse may at least be partly overcome or prevented. Such measures cannot reduce a dislocation, however incomplete; but they may so improve the tone of the muscles inserted into the capsule of the joint that it will hold the head of the humerus firmly within the glenoid, thus giving a more stable leverage for the other muscles to work against, and also prevent the head of the humerus from slipping out and stretching the capsule more and more. In this connection it is only necessary to mention the operation of nerve anastomosis which has been more or less successful in improving the function of arms that have suffered from paralysis of the brachial plexus. The results of treatment of this condition, whether developmental or paralytic in origin, have been extremely unsatisfactory. Krönlein reports from Langenbeck's clinic five cases of congenital dislocation of the shoulder out of a total of ninety-eight congenital dislocations. In regard to treatment Porter, quoted by Young in his "Atlas of Orthopædic Surgery," reports thirty-nine cases in which the results were very nearly uniformly poor.

Congenital Dislocation of the Elbow.—Dislocations of the elbow are not as common as some of the other congenital misplacements. Blodgett * has recently reviewed the literature and reported two new cases. Kirmisson thought it worth while to make a distinction between the dislocation of the radius alone and the simultaneous dislocation of both bones of the forearm at the elbow joint. According to Hoffa, up to 1898 there had been only two cases of radial dislocation alone. One of these had been recorded by Chaussier and the other by Hoffmann. Subsequently to Hoffa's citation of these two cases, Bonnenberg † reported a much larger series of the isolated dislocations of the radius. This deformity seems peculiarly likely to be associated with other congenital defects such as club foot, club hand, and others.

One of the most striking examples, in the literature of the hereditary tendencies in some of these deformities, is the family cited by Abbott,‡ in which during four successive generations there were seven cases of congenital dislocation of the head of the radius. The deformity is obvious, the majority of the dislocations being backward. A few are forward displacements, and fewer still are lateral. It is said that they are characterized by hypermobility as distinguished from the fixedness of traumatic displacements. Functionally there is considerable disability. A false joint is often established above the humeral condyles, and in quite a few cases the radius and ulna have been fused at their upper ends.

In the treatment of this condition it is evident that little can be done short

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* Blodgett: Journal of the American Orthopedic Association, January, 1906.

† Bonnenberg: Zeitschrift f. orth. Chir., 1893, 4te Heft, Band ii., p. 376; *ibid.*, iii., Bd. xx.

‡ Abbott: Transactions Path. Society, London, April 5th, 1892.

of some operative measure. Partial or complete resection of the head of the radius with enough of the ulna, where this bone is concerned in the dislocation, to permit of reduction of the deformity, represents the customary practice of those who have attempted to deal with these deformities surgically. An improvement in the appearance of the joint may be expected to follow such procedures, but no very decided betterment of function should be anticipated.

Congenital Dislocation of the Carpus.—Nearly a hundred cases of this deformity have found their way into the medical literature. Congenital dislocations of the wrist are hardly separable from congenital club hand. In fact, it would probably simplify the nomenclature of deformities of the carpus, of congenital origin, if the various types of displacement of the carpus upon the radius and ulna were regarded as variants of a congenital club hand; just as it would simplify the nomenclature of deformities of the tarsus if congenital club foot could be made to include valgus as well as varus deformities. In a recent study of the subject, E. Estor * has recorded the cases of this deformity which have gotten into medical literature, and he presents a careful analysis of the types of deformity described under this head. Madelung first called attention to the condition in 1878.

Estor maintains that the deformity, which is shown very well in Figs. 527 and 528, is congenital. These illustrations were taken from a case which served as the basis for Estor's study of this subject and is briefly outlined in the footnote.†

He believes that trauma, either direct or occupational, causes an underlying congenital defect to be magnified. Kirmisson, in 1902, took the same view of the matter, and designated the deformity a progressive luxation of the wrist. In the series of cases cited by different authors there were nine in which the influence of heredity was notable. The anatomical defects which may be present and cause the deformity may concern either the length or the shape of the ulna; in either case the relation of the radius and carpus may be modified.

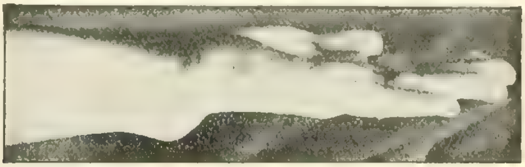

Fig. 527.—Photograph of the Left Wrist, showing (in profile) the Inferior Extremity of the Dorsal Aspect of the Congenitally Dislocated Cubitus. The same condition existed in the right wrist, though in a less marked degree. (After Estor, in the *Revue de Chirurgie*, Paris, August 10th, 1907.)

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* Estor: Revue de Chirurgie, xxxvi., August 10th, 1907.

† "This case is that of a woman thirty-one years of age. It was ascertained that her father's wrists were similarly deformed; the prominence, as in the case of the daughter, being more conspicuous on the left than on the right side. The patient affirms that, so far back as she can remember, her wrists had always presented the deformity shown in the picture, and her parents state that it was observed by them immediately after her birth."

The radius may also undergo changes in shape and alterations in length, which in turn modify its relation with the carpus. There may also be modifications in the shape of the carpal bones.

Madelung's deformity or luxation seems to be much more commonly noted in the adolescent than it is in the early years of life, and it is four times as common among girls as it is in boys.

When it was confined to one wrist, as it was in the eighty-five cases reported by Estor, in one-fifth of the total it was a little more frequent on the left. The evidence seems to point to the deformity being due to a congenital laxity of the inferior radio-ulnar articulation, which exists from early infancy and declares itself in adolescent life because of some traumatism to the wrist, or because of occupational strains to which it may be subjected, from time to time, in the course of routine use.

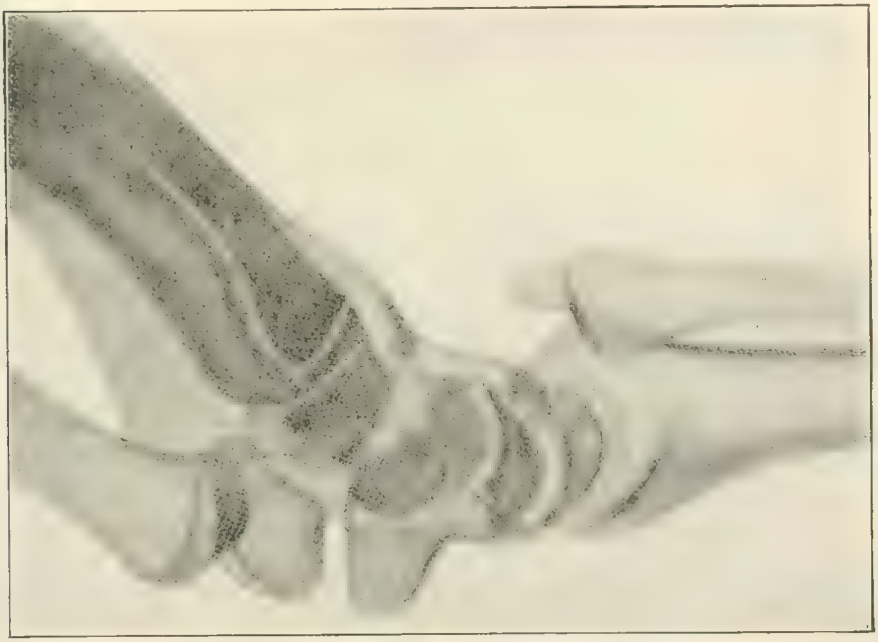

Fig. 528.—x-ray Photograph of the Left Wrist (the same case as that shown in Fig. 527). The points to be noted are: The os magnum is more voluminous than is normal, and it appears to have pushed upward the os semilunare, which in turn has pushed up the radius; the articular surface of the inferior extremity of the radius is no longer at right angles to the axis of this bone—a condition which predisposes to forward dislocation of the carpus; and the cubitus has lost its proper relations to both the carpus and the radius. (After Estor, in the *Revue de Chirurgie*, Paris, August 10th, 1907.)

The appearance of the radio-carpal articulation undergoes modification. The antero-posterior diameter is markedly increased. In some cases the long axis of the hand is deviated to the ulnar, sometimes to the radial, side. Viewed from the side there is usually more or less backward luxation of the ulna. The contours of the radial and ulnar sides of the wrist are quite perceptibly altered in this deformity: and palpation over the ulnar styloid, the radio-carpal articulation, and over the pisiform bone is often quite painful. The functional symptoms vary from a condition in which the patient is very little handicapped to one in which no use of the wrist is permitted. Flexion is very often restricted in the motions of the wrist, though occasionally cases have been noted where there was abnormal palmar flexion. Dorsal flexion is often considerably restricted. The other motions of the wrist are usually somewhat impaired, but the chief disability concerns flexion and extension.

In regard to the treatment of this condition, there is but little need of doing anything in those cases in which functional disability is not marked. As this feature becomes more pronounced there is greater and greater need of instituting treatment. Various forms of retentive apparatus have been devised, furnishing more or less complete fixation to the lower end of the radius and ulna. Massage, electricity, and other forms of physical therapy are useful adjuncts in treatment. In the severe cases, however, local treatment such as has just been outlined will fail to yield satisfactory results, and operative measures will be found necessary. Tenotomy, arthrotomy, and reduction through the operative wound, linear or oblique osteotomy of the radius, and wedge-shaped osteotomy of the radius represent the measures which have been tried. The one

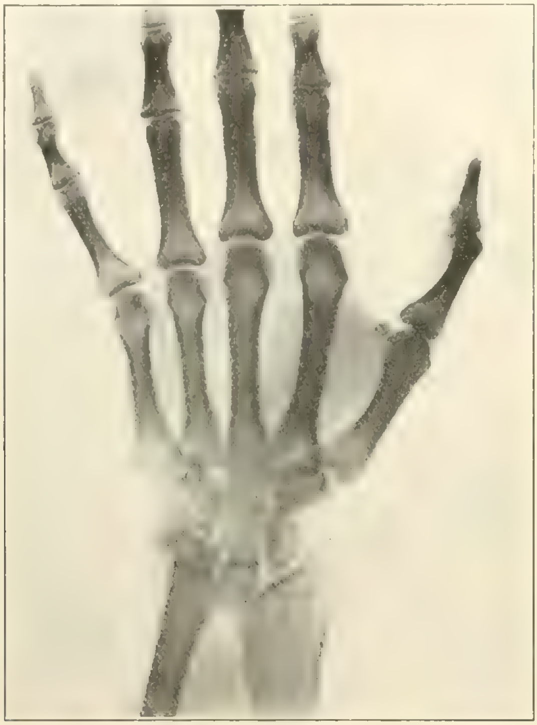

FIG. 529.—Left Wrist. Note the inclination of the articular face of the ulna and the separation of radius and ulna. Compare Fig. 530. (Original.)

which has given the best success, and which Estor advocates in his monograph, is an osteotomy of the ulna in preference to, or in addition to (in some cases), the more frequently performed osteotomy of the radius. In the foregoing description the writer has made free use of the account of this condition as given by Estor, and here puts on record a case which occurred in the practice of an associate and has not been previously published.

The case is that of a young woman of nineteen or twenty years of age, who was very athletic in her tastes and participated in many outdoor sports. She noticed a gradually increasing disability of the left wrist, which in the course of several months virtually prevented her from undertaking anything requiring the expenditure of force through her left arm and hand. There were not only weakness and inability to exercise the functions of the wrist muscles, but pain was caused by any attempt at use. There was some slight distortion of the wrist with limitation of motion; and examination with the *x*-ray revealed the condition shown in Fig. 529. Fig. 530, which is the right wrist of the same person, is inserted for comparison. After a fair trial with conservative treatment it was proposed to correct the deformity by operative measures; and an osteotomy of the radius and ulna was performed, the ulnar fracture being united with a silver wire. The functional result has been nearly perfect, and now

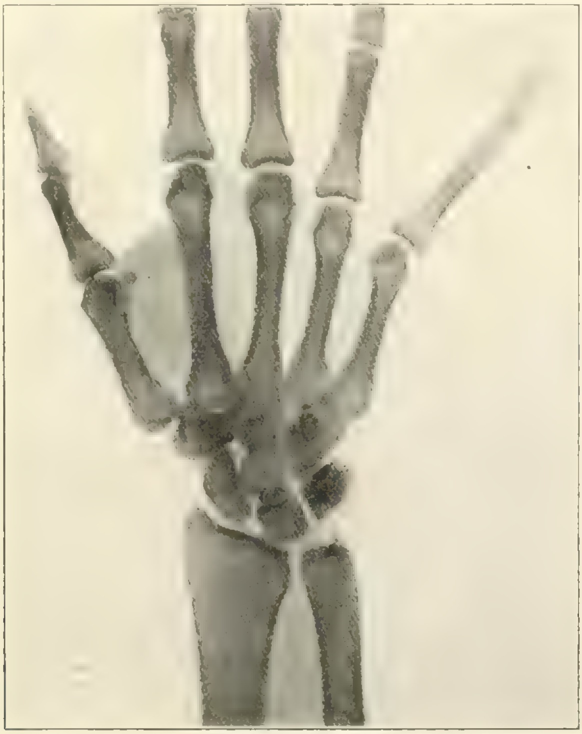

FIG. 530.—Right Wrist. Observe the relation of the carpus to radius and ulna and compare with Fig. 529. (Original.)

after over five years there is no practical impairment of the usefulness of the arm. (Vide Figs. 531, 532, and 533.)

There are, occasionally, total absences of the radius which cause luxations of the carpus upon the remaining bone, the ulna. Such displacements constitute the true congenital club hand. The character of the deformity is at once apparent and the *x*-ray may be called upon only to determine the exact anatomical defect.

Treatment consists, in the early stages, in manipulations and massage. Occasionally operative correction is indicated, and such procedures usually concern themselves with the carpus. Tenotomies, resections of a part of the ulna and sometimes of portions of the carpus may be necessary before reduction of the deformity is possible.

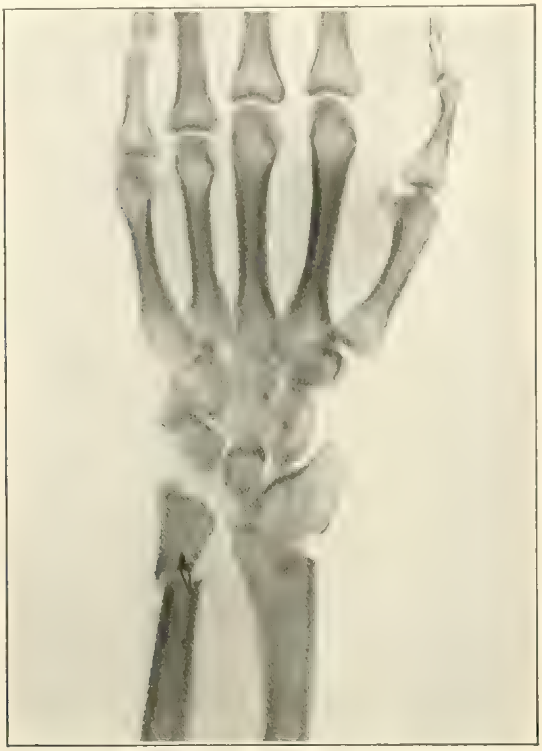

FIG. 531.—Same Case as that Shown in Fig. 529, Six Weeks After Osteotomy. (Original.)

CONGENITAL DISLOCATION OF THE HIP.—There have been very few subjects, among the group of diseases which the orthopædist and the surgeon have been called upon to treat, which have aroused more discussion than congenital dislocation of the hip. One can scarcely take up an orthopædic publication without finding one or more articles on this subject, and this is particularly true of the foreign journals. There does not seem to be any abatement in the interest which the subject attracts as time goes on. The reason for this is, doubtless, to be found in the fact that the problem is still unsolved, and therefore the interest of the surgeon is constantly spurred on to fresh endeavor. The visit of Professor Lorenz to this country, a few years ago, served to arouse an interest in the problem of congenital dislocation upon this side of the water; and many more cases of this condition are being recognized and treated at the present time than ever before. As has been said earlier in this article, the subject has been treated by surgeons as though there were no greater obstacles in the way of reducing a dislocation of this sort than there are in the way of the reduction of a traumatic dislocation. Until the *x*-ray became developed to such a point that it was of service in revealing the shape of the head of the femur and the depth of the acetabular cavity, the anatomical defects at or about the hip joint were not appreciated. Valuable as this has been in throwing needed light upon the subject, its employment is attended with certain limitations, which make it undesirable to rely upon the *x*-ray as an infallible test of the conditions present within the socket of the hip joint. There are so many possibilities of distortion of the actual conditions, and at the same time there are so many departures from the normal relations of the head, neck, and acetabulum, that the possible errors of interpretation, when the *x*-ray is employed as a guide to the condition, are almost infinite.

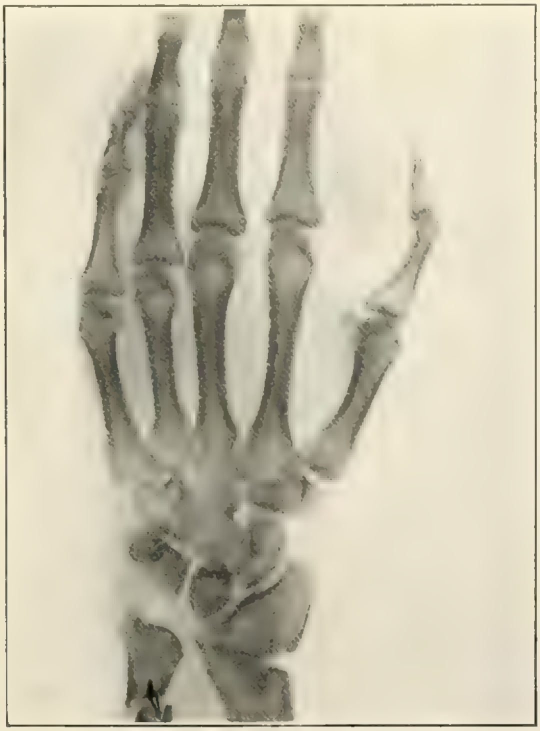

Fig. 532.—Same Case as that Shown in Figs. 529 and 531, Four Months After Osteotomy. (Original.)

Historically, congenital dislocation of the head of the femur has been recognized since the dawn of medical writing. Hippocrates, Galen, and Avicenna were among the earliest observers of the phenomena of disease and are likewise the first to have spoken of these conditions at the hip joint. After Paré's time there was a long hiatus before other observers began to describe this deformity; and from the middle of the eighteenth century we find cases more frequently reported, and more men interesting themselves in the dislocation. After the beginning of the nineteenth century such names as Palletta, Dupuytren, Delpèche, Pravaz, Malgaigne, Guérin, Parise, Dollinger, Buckminster Brown, Bradford, Hoffa, Lorenz, von Mikulicz, and many others are constantly recurring in the literature as contributing something to the understanding of this most troublesome anatomical perversion. The recent orthopædic literature,—that is, that of the last ten years,—is teeming with references, citations of cases, contributions to the study of the anatomy of the parts, or suggestions as to treatment.

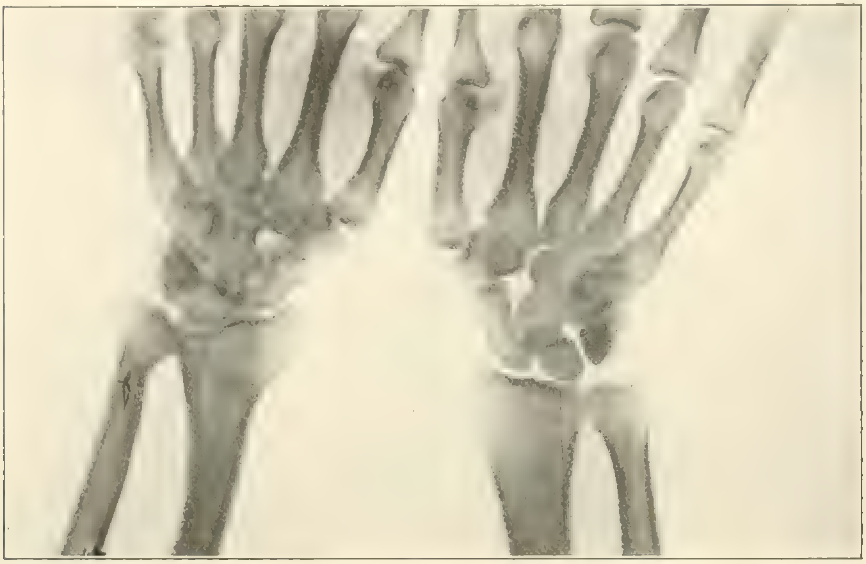

FIG. 533.—Same Case as Figs. 529 and 530, Five Years After Operation. Observe the improvement in the relation of the carpus to the radius and ulna; but note the abnormal shape of the left ulna, and the wider separation between the radius and ulna on the left. (Original.)

Congenital dislocation of the hip is a condition of great frequency among congenital deformities. It stands next to congenital club foot in frequency of occurrence. For some reason, congenital defects of this sort affect girls more frequently than boys. In one series of two hundred and fifty-three cases recorded by Lorenz, two hundred and twenty-three were in girls, and this has been about the proportion ordinarily noted in collected series of cases. There seems to be nothing particularly significant about the right and left sidedness of the deformity, or the relative frequency with which the bilateral cases occur with reference to the unilateral. In some series the left side seems to be more frequently at fault, in others the right. Unilateral cases are more common than bilateral.

Pathology.—The fundamental disturbance causing this deformity seems wrapped in mystery. None of the theories thus far advanced can be proven. It is difficult to secure the facts which it is desirable to have, to arrive even at a reasonable theoretical hypothesis. Among the theories which have had the widest acceptance and the most distinguished advocacy are, in the first place, those which are based upon some pathological alteration in the joint, and secondly, those which concern themselves with developmental processes.

Under the first theory, traumatism during uterine life and at birth must be considered, and also joint disease in prenatal life, and primary defects in the nervous system causing paralysis of muscles concerned in holding the head of the femur against the acetabulum. Malposition in utero, consisting of strong flexion of the thighs upon the abdomen combined with adduction, has been described as a cause in some cases observed. Alterations in the conformation of the amniotic sac, or in the amount of fluid which it contains, may have had some influence upon the maintenance of this faulty position. Certain it is, that such a position would tend to the production of a luxation of the femoral head which might easily enough become a true dislocation when function of the limbs was attempted. There seems very little to support the view that traumatism at birth has had anything to do with the causation of any considerable number of cases. The same may be said with reference to precedent intra-uterine joint disease. There is no evidence to substantiate this view. Any disease which would cause such dislocations, should leave, at least, a certain number of joints stiff; and furthermore, it would run counter to most of our experience to find any joint disease which would select two hip joints simultaneously as frequently as double congenital dislocation occurs among dislocations of the hip. Of the paralyses which could possibly produce a luxation of the femoral head, anterior poliomyelitis is the most likely; but the neurologists say there is no evidence tending to show that this affection ever occurs before birth.

The theory of arrested development is the one which has perhaps the most and the ablest defenders; and certainly it is the one which a study of the abnormal anatomy of the parts concerned in the construction of the joint would indicate as correct. How much the arrest of development has to do with embryonic defects, and how far it is influenced by abnormities of intra-uterine pressure or position, it is impossible to say. The influence of functioning upon development during the early weeks and months of infancy is an indeterminable question. The part played by weight-bearing and functioning during walking, after the child is old enough to propel himself about, can perhaps be surmised a little more readily, but is capable of no scientific demonstration.

Pathological Anatomy.—A considerable number of cases of congenital dislocation of the hip has been studied at autopsy; and the modern perfection of the *x*-ray makes possible a better understanding of the anatomical conditions at the hip joint than it was possible to obtain before its employment was as

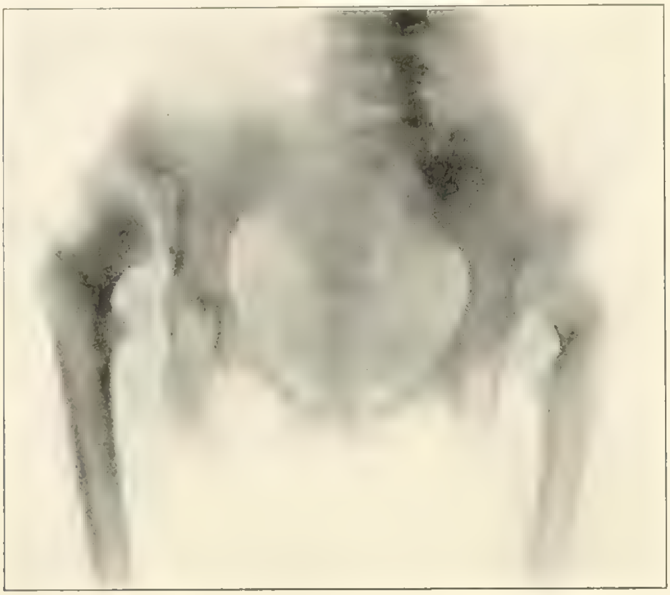

FIG. 534.—Observe the Coxa Valga of the Left Hip and Contrast with the more Normal Relation of the Neck and Head in the Right. Note the rudimentary acetabulum on both sides and the false acetabulum on the side of the ilium. In this case the patient was a child of thirteen years. (Children's Hospital, Boston.)

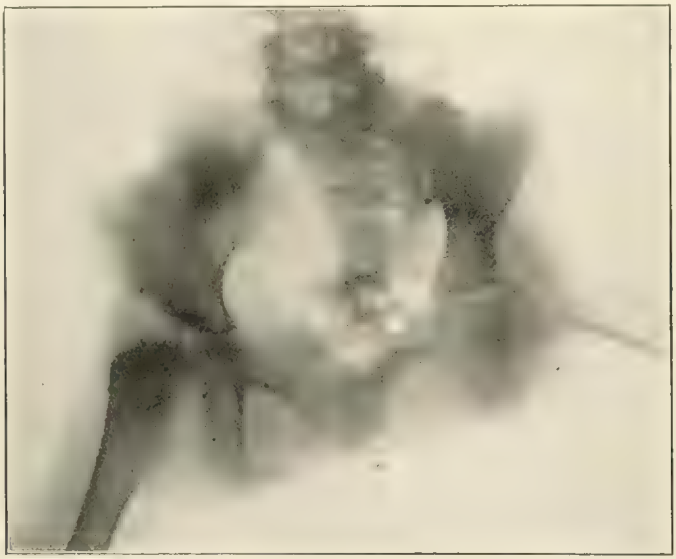

FIG. 535.—Same Case as Fig. 534, After Machine Reduction. (Children's Hospital, Boston.)

constant as it now is. Tillmanns* shares the belief of Dupuytren and Roser that there is a lack of development of the acetabulum and the cotyloid ligament, which, combined with an adducted position of the thighs during uterine life, accounts for the deformity. He also believes that the shape of the female pelvis is a factor in the causation of a dislocated hip. Cunningham has shown that the anatomical peculiarities of the female pelvis are notable in the human embryo as early as the third or fourth month of fœtal life. Grawitz also champions the defective-acetabulum theory. Dollinger believes there is evidence in some cases of a premature ossification of the Y-ligament. Certain it is, that there is a rudimentary acetabulum in very many of the cases; and this is perhaps more constant than a rudimentary head to the femur. Imperfectly developed femoral heads are quite constantly seen; and this imperfection in development is not confined to the head of the bone alone, but extends to the neck as well. Besides the defects in the development of these two structures, there are many twists in the femoral neck which are not the result of any failure in normal development, but are caused by muscular pull and abnormal pressure or tension.

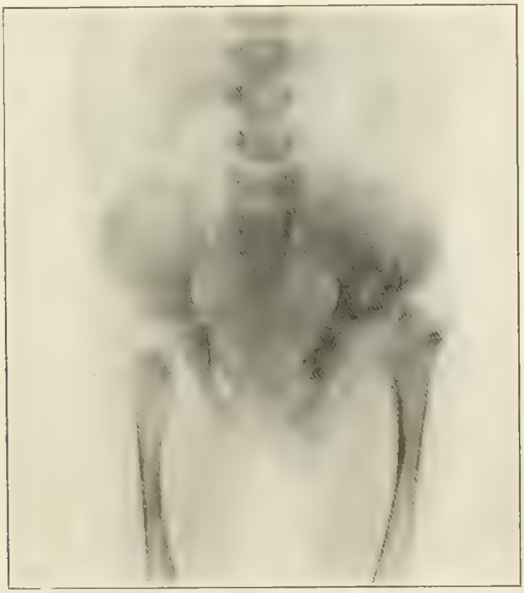

Fig. 536.—Acute Dislocation from Infectious Arthritis, Normal Acetabula. (Children's Hospital, Boston.)

Some form of coxa vara is thus very constantly produced in congenital dislocation of the hip. Because of the defective development of the femoral neck the usual relation of the femoral head and the acetabulum is that of a coxa valga. (Figs. 534 and 535.) The defects in the development of the acetabulum consist chiefly of a filling up of the socket with a fibro-cartilaginous material;

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*Tillmanns: "Textbook of Surgery," vol. i., p. 772.

but more particularly the ledge at the border of the acetabulum is so shelving that it forms no obstacle to the slipping of the femoral head from the socket. Fig. 536 shows an *x*-ray of a child whose left hip was dislocated in consequence of an acute infectious process in that joint. The normal character of the acetabulum is well shown in this case on the dislocated and the undislocated side. Here there is a good ridge at the top of the acetabular cavity. Contrast the appearance in this case with that shown in Figs. 534 and 535. Changes in the shape of the head are not quite as striking as is the case in the acetabulum; but

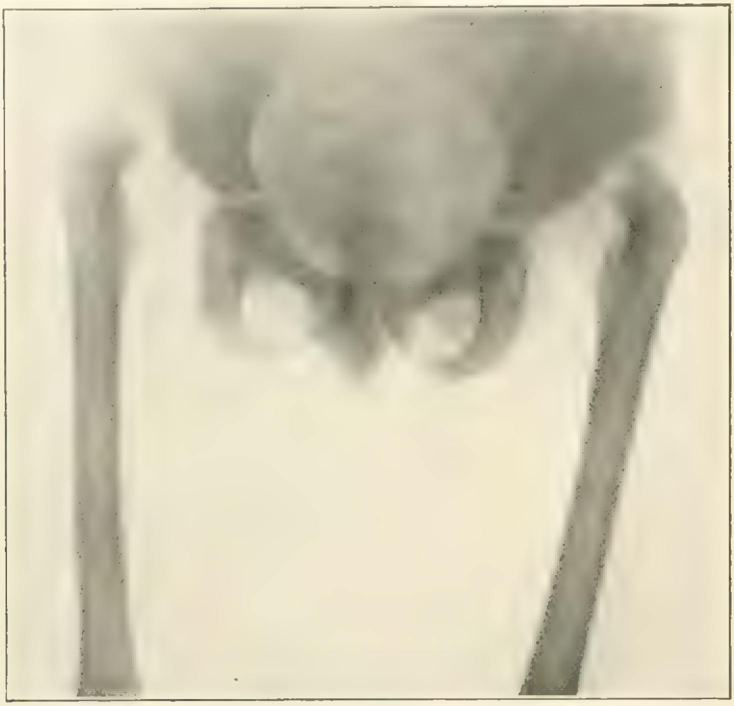

FIG. 537.—Congenital Dislocation of the Hip. (Children's Hospital, Boston.)

the absence of anything like a normally developed neck, or a neck which though normally developed is so distorted that it does not connect the head in a normal manner to the shaft of the femur, is capable of rendering unstable the relations of the head with the acetabulum. It is not difficult to understand how a short neck like that shown in Fig. 537, when combined with a coxa-valga relation of the neck with the shaft, should predispose to a dislocation. The development of the upper epiphysis of the femur undergoes considerable modification, as is shown in Fig. 538, where there is opportunity to contrast the shape and size of a normal with an abnormal upper femoral epiphysis. Fig. 539 affords a very good illustration of the reason for a dislocation when the development of the head and neck of the femur of the dislocated side is not materially different from that of the sound side, and the angle of deflection of the head is not essentially unlike that of the non-dislocated side, whereas the acetabulum is filled up with an irregular, jagged mass of fibrous tissue, and there is almost an entire absence of any ledge against which the head of the femur can rest. As a result of these osseous derangements at the hip joint there are secondary changes in the fibrous capsule of the articulation. As the head of the femur slips up out of the socket, the capsule becomes stretched, and the more remotely the head of the bone becomes removed from the acetabular cavity, the more narrowed the connecting funnel-shaped capsule becomes. In extreme cases the capsule becomes elongated into an hour-glass-shaped structure with only a narrow orifice between the two expanded ends, and through this narrow constriction the head of the bone must be made to pass if it is to reach the socket from which it has been removed. The elevated position of the femoral head has a still further effect upon the muscles having their insertion into the trochanter and capsule of the joint. The normal balance between these muscles is destroyed, and some of them are stretched out beyond their normal lengths, whereas others are shortened and contracted. In addition to the effects which have just been mentioned in connection with the muscles, there is doubtless an element of muscular impairment which results from inability to function properly. Young calls attention to the integrity of the fibrous capsule of the hip joint as evidence

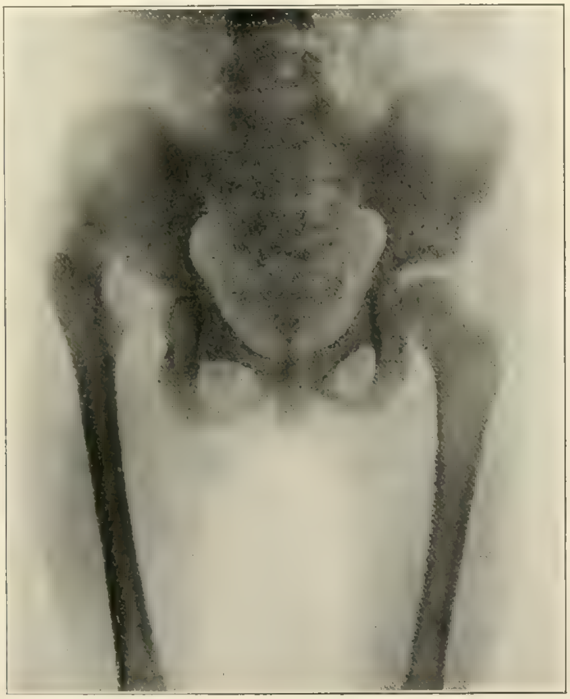

FIG. 538.—Contrast Shape and Size of Upper Femoral Epiphysis in the Two Sides; also the Length and Angles of the Neck. (Children's Hospital, Boston.)

that this condition is not a true dislocation, an essential feature of which is a rupture of the capsule; hence it should rather be considered the result of a failure to develop in a normal manner. In many cases at operation the existence of a false acetabulum upon the side of the ilium is demonstrable, and it is also often in evidence in the skiagram, as may be seen in Fig. 539. The fact that a false acetabulum may be formed by pressure of the femoral head against the side of the iliac bone, is cited as proof of the ability of the head of the femur to bore out a cavity for itself in the original imperfectly developed acetabulum. Those who assume that such an outcome is likely to happen when the head is replaced, seem to ignore the fact that defects in the relation of the neck to the shaft, as well as misshapen heads, make the exercise of the compression necessary to the deepening of an acetabulum much more difficult than it is at the seat of the faulty acetabulum, and, furthermore, that even the false acetabulum has no stability. When the head of the femur has arrived at the point where it tends to form a new socket for itself, it has gone as far as it can go; and a shallow, imperfectly constructed socket is as good as a more perfect one. It by no means follows that were the head replaced in the old cavity it would be any more inclined to remain there, even though it could ream out for itself in that situation as deep an acetabulum as it had produced on the side of the ilium. In fact, the whole natural tendency would be toward a reluxation, for reasons which are perfectly obvious. If

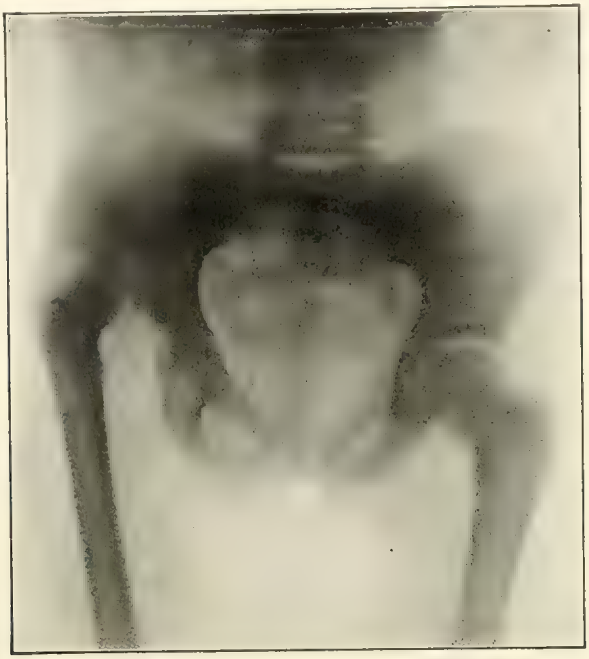

Fig. 539.—Equilateral Dislocation. (Children's Hospital, Boston.)

replacement could be accompanied by remodelling of the shape of the head and neck of the femur, as well as deepening of the acetabular cavity and alteration in this structure itself, there might be some hope of a satisfactory readjustment of anatomic conditions. One other part of the normal structure of the hip joint undergoes some modification in congenital dislocation of the hip, and that is the cotyloid ligament. In the earlier cases, at autopsy and operation, the cotyloid ligament is usually present, though often much elongated and correspondingly thinned. In the older cases, after the eighth to the tenth year, it has not often been found, having apparently undergone absorption, there being no longer any need for its existence.

Symptomatology.—Recognition of congenital dislocations at birth is quite difficult and is rarely accomplished. Sometimes in the earlier months of infancy the mother or nurse may detect a prominence in the buttock formed by the trochanter, or a click may be noticed in the hip joint when the hips are manipulated, but usually it is not until the child commences to stand and walk that the condition is suspected. For considerable periods even after this time, particularly in the bilateral dislocations, peculiarities in gait may be attributed to the natural, tottering instability of babyhood. The absence of the subjective signs of pain or impairment of health favors the belief that mere peculiarity in gait may be ignored, and that as the child develops it will be outgrown. There comes a time, however, when this illusion is dispelled by the closer observation of parents or friends, and the surgeon is consulted.

In the unilateral cases the gait is quite significant. The child walks with a decided limp, yielding on the side of the dislocation, but without any suggestion of discomfort or limitation in the arc of motion. In the bilateral cases there is the same absence of any suggestion of discomfort in locomotion, but there is a decided roll of the trunk from side to side as the child successively attempts to shift its weight over its altered centre of gravity. There is always an exaggeration of the lumbar lordosis, which is most marked in the bilateral cases. The buttocks are very prominent, and in the older children particularly the prominence of the trochanters is noticeable posteriorly to their usual location. In the unilateral cases there may be some atrophy of the thigh and calf which is, of course, not so noticeable in double dislocations. The trochanter is above Nélaton's line, and seems situated in a plane posterior as well as superior to the customary location. Shortening is conspicuous in the unilateral dislocations, but is a feature which can usually be overcome to a greater or less extent by traction upon the femur, and during this procedure the up-and-down excursion of the trochanter can be noted. The head of the femur cannot be detected in its customary place immediately beneath or slightly to the outer side of the femoral vessels at the level of Poupart's ligament. Mobility of the joint is quite free, and where it is at all limited the restriction is not due to muscular spasm but to some mechanical obstacle. Adduction, hyperextension, and rotation may be somewhat restricted, but flexion is commonly abnormally free. The adductors of the thigh are often taut, and are put on the stretch very early in attempted abduction. The hamstrings are also inclined in some cases to be tightened, causing an obstacle to complete extension at the knee.

Knock-knee, valgus, and scoliosis are not infrequently caused by this deformity, and combined with it as an associated deformity there are occasionally found other congenital defects, such as club foot and spina bifida. The diagnosis of this condition is therefore not a very difficult one to make. Hip disease of tuberculous origin, coxa vara, and paralytic dislocation of the head of the femur represent practically the only conditions which it is needful to bring into the differential.

Treatment.—Where there has been so much obscurity as to causation for a deformity, and where so many modifications of structure enter into the composition of the parts concerned, it is not strange that there has been much uncertainty as to the best method of treatment. From the year 1829 when Dupuytren, after a careful anatomical consideration of the matter, came to the conclusion that its cure was not feasible, down to the present time, when there are those who regard congenital dislocation of the hip as one of the conditions in which cure can be almost guaranteed if treatment is undertaken at the right time and in the right way, there have been all varieties of opinion. The urgency for the discovery of some method of treatment which shall effect a cure, is just as great as it ever was. Adults afflicted with this deformity are often greatly incapacitated, and suffer much from pain and fatigue as well as from the em-

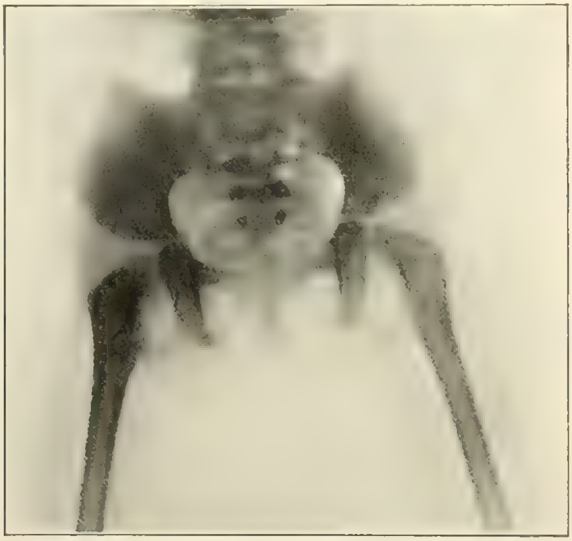

FIG. 540.—Double Congenital Dislocation of Hips, Nine Months after Reduction; Function just Being Permitted. (Children's Hospital, Boston.)

barrassment which always attends a disfiguring deformity. Economically, they are sufferers, as well as physically.

To the writer it seems that one of the conclusions, which Dupuytren originally drew, is still true, that there are anatomical reasons why congenital dislocation of the hip cannot be cured. The work of Hoffa, Lorenz, and others has demonstrated that the second of his conclusions, that palliative measures are equally hopeless, is untrue. There is no discounting the fact that improvement in the position of the head of the femur can be secured in a considerable proportion of the cases, and that this improved position may be permanently maintained. A few cases, unquestionably, are reduced, and anatomical cures are secured. The permanency of these cures is problematical, and is wholly dependent upon the approximation to the normal of the parts concerned in the make-up of this articulation.

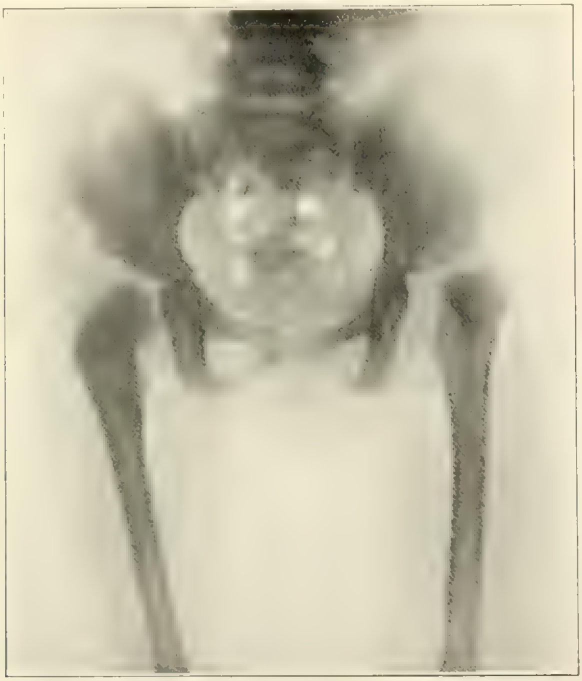

Fig. 541.—Same Case as that Shown in Fig. 540, Two Years Later. Observe the reluxation of the left hip and a commencing luxation of the right. This condition has been gradually developing. (Children's Hospital, Boston.)

Some cases which are immediately satisfactory are showing a tendency to reluxate, as is shown in Figs. 540 and 541. This doubtless occurs more frequently than is recognized, and time sufficient to determine the final results of cases which have been treated by the more perfect methods of Lorenz, has not yet elapsed. In this country there has been a great tendency to strive for some short cut in the post-operative treatment; so that in all probability, the results here will not show so high a percentage of permanent benefit as where conservative post-operative treatment is followed for a longer time.

In considering the method of treatment to be followed in a given case, a careful preliminary study of the anatomical conditions is required in order that the best plan may be followed. One is always confronted with the troublesome fact, that it is impossible in many cases to form a correct estimate of what these anatomical conditions really are, and it is often necessary to make an examination under ether before one is in a position to determine what the chances of success are likely to be. The difficulties are not by any means overcome when the head is brought down opposite the acetabulum, and slipped into the socket. On account of the twists in the neck, or the conformation of the head, it is often necessary to maintain relations between the shaft of the femur and the acetabulum which do not permit of normal function; and if in this position the head can be kept in the socket, it may require an osteotomy, after stability has been secured, to permit of use of the limb.

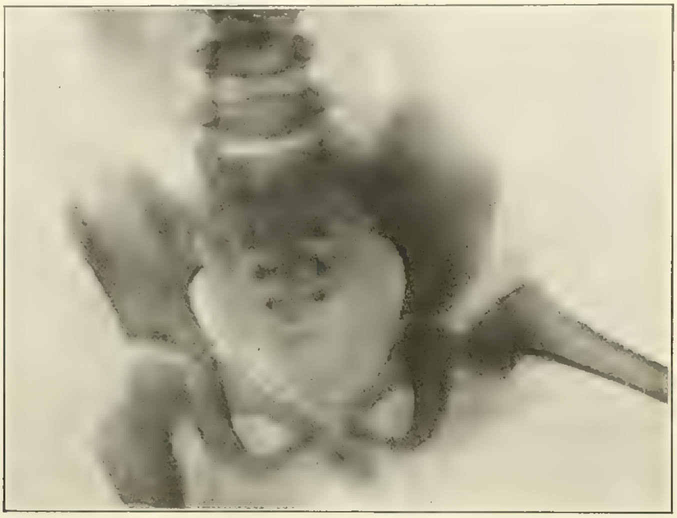

Fig. 542.—Rudimentary Head and Acetabulum and Good Reposition of Head in Socket, but the Anatomical Conditions Are Apparently Unfavorable for a Permanent Cure. (Children's Hospital, Boston.)

To Hoffa belongs the credit of having first demonstrated the feasibility of deepening the acetabular cavity and replacing the femoral head within the socket by an open or bloody reposition. The applicability of this method is restricted to those cases of unilateral deformity in which bloodless reduction has failed, or where the age of the patient precludes the possibility of securing satisfactory functional results by such an attempt. Even with the assistance of the various mechanical aids to reduction, failure is the result in the majority of cases after puberty. Such an operation contemplates the establishment of a stable articulation by a more or less firm osseous or fibrous ankylosis, in a position where the weight of the body is borne through the normal centre of gravity. In bilateral cases this method is not applicable. The operation itself is difficult, both because of the obstacles to reduction offered by the contractures of muscle and tendon, and because of the deep-seated position of the acetabulum and the fact that it is sometimes hard to identify it and ream it out when it is found. Special curettes and burr drills have been devised to facilitate the procedure.

The bloodless method is attended with its greatest successes during the period between the second and third and the sixth or seventh years in the hands of the most skilful manipulators. The percentage of cures is higher by five or six per cent in the unilateral cases than in the bilateral. Complete overcoming of the contractures of all muscles whose shortness or tautness could interfere with the reposition of the head in the old acetabulum is a prime essential of the operation. This having been accomplished, and the ability easily to abduct and hyperextend the thigh with the head of the bone at least opposite the acetabulum having been demonstrated, the femoral head may be slipped over the rim of the acetabulum; and this takes place with a click which is commonly audible, but is sometimes only palpable. When this can be accomplished it should be possible to palpate the head of the femur just below the femoral vessels at Poupart's ligament.

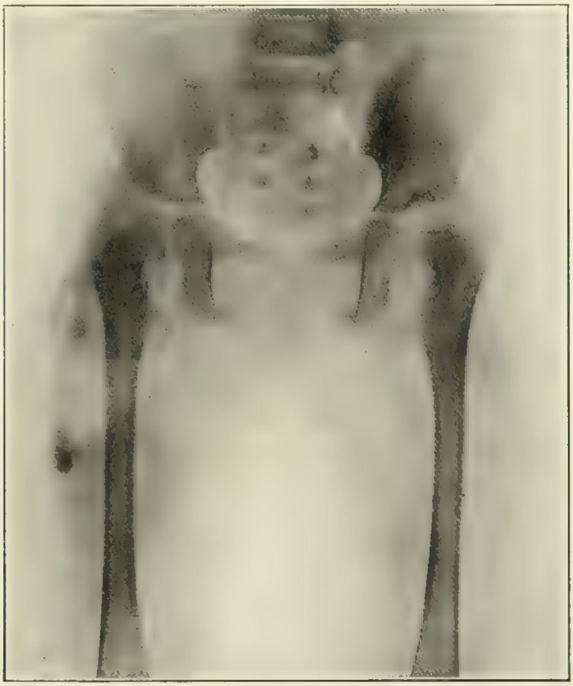

FIG. 543.—Showing Tendency to Redislocation One Year after Reduction. Rudimentary acetabula apparently the cause for the reluxation. Same case as that shown in Fig. 542. (Children's Hospital, Boston.)

By rotating the femur the head is more readily recognized. In order that it should remain there and not immediately become dislocated again as soon as the force which replaced it is removed, it may be necessary strongly to invert or strongly evert the foot; and the position which the thigh takes when reduction is completed is that of ninety degrees, more or less, of abduction, and flexion to nearly the same amount in the majority of cases. This position is well shown in Fig. 542. Fig. 543 shows very well that, although reduction in this child, who was eight years of age, was brought about, and though it required machine reduction to accomplish it, the chances are strongly in favor of its being reluxated because of defects in the formation of the head. It is difficult to see how, even if the acetabulum should be deepened by the pressure of that rudimentary head, any proper development of the head itself is to be brought about; and if the latter is not secured no stability can be reasonably anticipated in this joint. In Fig. 544 there is a slightly better developed head than that shown in Fig. 543 on page 759, but the chance for reluxation seems good. When the preliminary steps have been thoroughly carried out and replacement of the head has taken place, then, in those cases where success is to be attained, spontaneous luxation ought not to be easy before the plaster is applied or is being applied. As a preliminary to bloodless reduction, traction in bed for several days previous to etherization often facilitates the manipulations, and at the time of the operation kneading massage to the tautened adductors assists in overcoming their tension. Machines, such as those devised by Bartlett and Bradford in this country and by

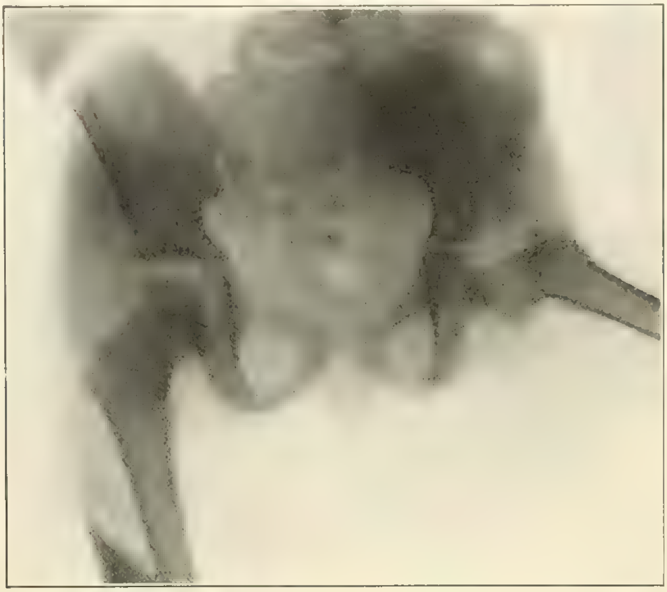

FIG. 544.—Compare with Fig. 543, p. 759. Three Months after Reduction. (Children's Hospital, Boston.)

Lexer and Heusner abroad, facilitate the stretching of contracted fasciæ and ligaments and fixation of the pelvis, which is so necessary during certain of the manipulations. Lorenz employs a simple wedge-shaped block of wood tc aid in the final sliding of the head into the acetabulum.

A considerable number of accidents have attended the employment of the force exerted in attempts to reduce the older cases, particularly by the machine methods. Ruptures of vessels and fractures of the femur and pelvis are the more serious of these, with an occasional injury to the great nerve trunks.

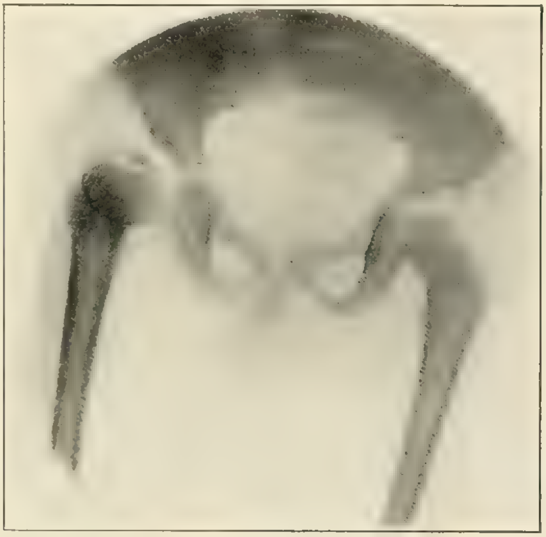

FIG. 545.—Attempted Reduction (not at the Hospital) of a Congenital Dislocation and Fracture and Impaction of the Femoral Neck. (Children's Hospital, Boston.)

Production of hæmatomata is common, but not often of serious consequence, and the same is true of the superficial tears in the skin.

At a machine reduction in a twelve-year-old child the writer fractured both pubic rami but without any troublesome consequences. Fig. 545 illustrates an impacted fracture of the femoral neck brought about in an attempt at reduction of a dislocation.

The after-treatment of these cases, both the immediate and the remote, is of great importance. The retentive spica should be put on with the utmost care while the child is still under ether, and while the limb is in the position where greatest stability is demonstrable, relegating to the future an osteotomy for the correction of possible faulty positions of the limb. If the head is in place and the acetabulum is to be deepened by the exercise of its compression force, prolonged confinement in plaster, accompanied by early institution of weight-bearing, should be the rule. The first plaster should be worn three or four months and then changed for one exactly similar, if the reduction is found at that time to be maintained. The treatment should be continued for from six to eight months longer, and then some lessening of the extreme position may be permitted, still under the protection of plaster spicas. In the course of three or four months more, the child may allow the position of the thigh to approximate the normal, and a thoroughgoing course of massage and active and passive manipulation should be continued, with intermittent fixation, for fully a year longer, making the entire treatment, after manipulative, bloodless reduction, occupy two years or more. If only an anterior reposition results from this it is worth while; for this is a much better functional condition than the original, and is more likely to be permanent than is an anatomical replacement where the condition of the acetabulum and the femoral head is rudimentary.

In Fig. 546 is shown a case where the shape of the femoral head, the development of the neck, and the angle of the neck with the shaft were not particularly faulty in either hip, but where the maintenance of the head in the socket for a year had failed to deepen the acetabulum and consequently redislocation was taking place. The "anterior reposition," which very often passes for an anatomical reduction, yields very good functional results and can be easily secured when the immediate results of attempts at anatomical replacement show an instability of the reduction. In the writer's opinion, where such is the case, it is much wiser to be satisfied with anterior reposition than to try for an anatomical cure and suffer the result which so frequently happens, even

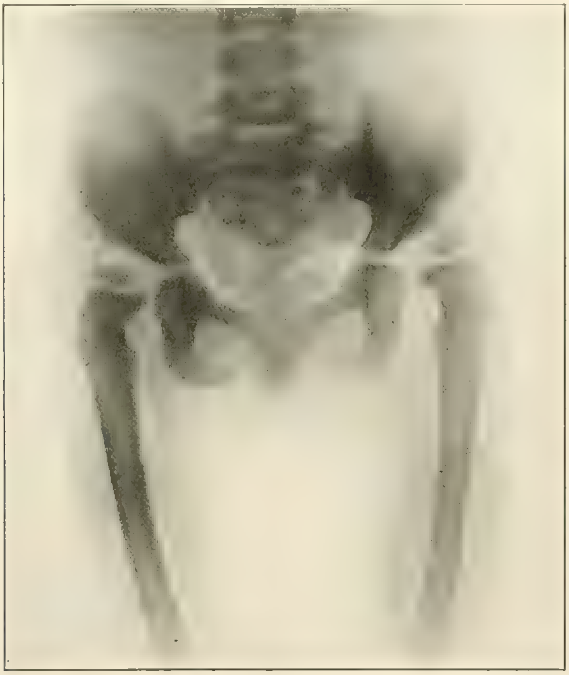

Fig. 546.—Before Bloodless Machine Reduction. Left head was out of the socket clinically and was replaced. Right was thought to be in place clinically. (Children's Hospital, Boston.)

while the patient is wearing the first retentive plaster. The tendency in these cases is to reluxate to the old posterior position. Statistics are notoriously untrustworthy on matters of this kind, and that they should be so is easily appreciable when one considers the difficulties of making accurate observations. The percentages of cure in congenital dislocation vary all the way from three to seventy-two per cent in the hands of various operators, as given by Lorenz and Reiner.* In view of the tendency to progressive redislocation, which has been shown in some of the illustrations presented in this chapter, even over considerable periods of time, it seems that the future of many cases reported as cures when retentive plasters are removed, will speak less favorably for anatomical reduction, though without doubt many will be functionally improved.

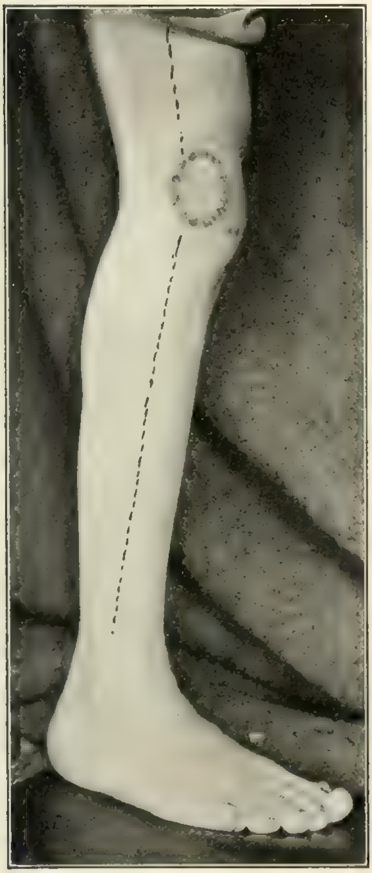

Fig. 547.

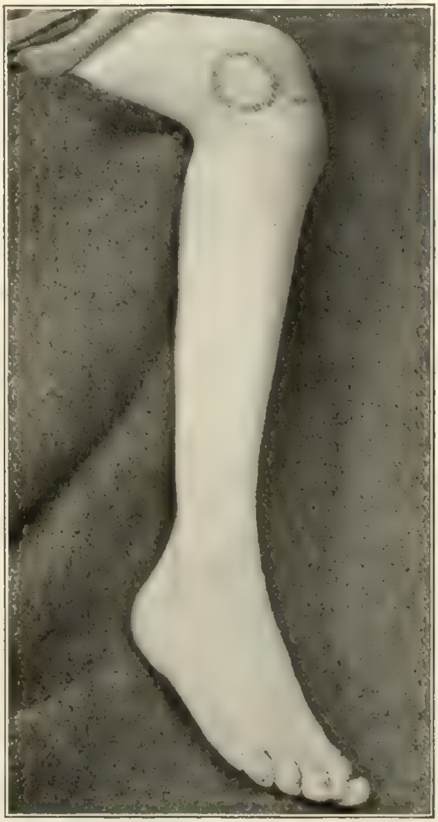

Fig. 548.

Fig. 547.—Patient Standing. Observe the direction of the pull of the quadriceps tendon. (Original.)
Fig. 548.—Side View of the Same Case as that Shown in Fig. 547. (Original.)

Apparatus has been employed without resort to operation in some bilateral cases with considerable success. In unilateral cases it has not been so beneficial. The brace which has been most efficient, has been a back brace to which is attached a pelvic band that encircles the pelvis at as low a level as can be worn and at the same time allow the patient to sit. In order to carry it as low as possible behind, the portion crossing the sacrum dips down just behind the greater trochanters, curving over them, and terminates in front at the anterior superior spines. The uprights, which are of tempered steel of about .16 gauge, do not fit in closely to the lumbar spine, but stand away from it. To these uprights is attached a leather abdominal belt about eight to ten inches in depth, which buckles in front, and by drawing this tight the lumbar spine is drawn in to the uprights and the weight of the body is shifted backward more nearly over the centre of gravity. By this procedure the gait is made less rolling, lordosis is slightly lessened, and the symptoms of fatigue and strain which these patients often complain of are considerably ameliorated. This has been especially advantageous in adults. It was also helpful in a bilateral dislocation in a child where bloodless reposition had failed. Apparatus

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* Joachimthal's "Handbuch der orth. Chir.," sechste Lieferung, p. 222.

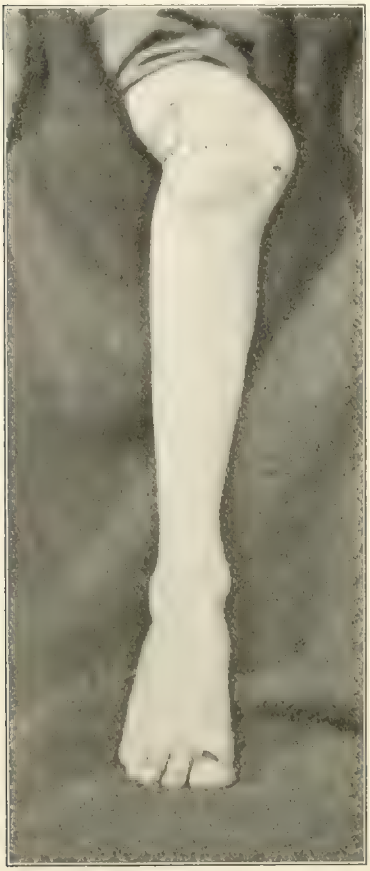

Fig. 549.

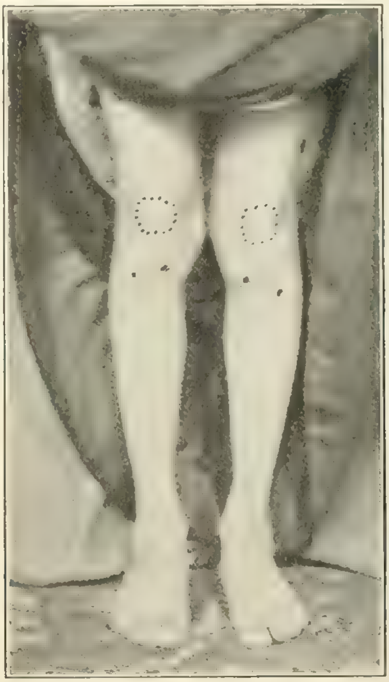

Fig. 550.

Fig. 549.—Circular Dotted Line Indicates the Position of the Patella. Observe the high position of the patella and the prominence of the internal condyle. (Original.)

Fig. 550.—Dots Indicate the Position of the Tibial Tubercles before and after Transplantation. Observe also the position of the patella. (Original.)

having for its purpose fixation of the trochanter by pads and modified spicas has not been satisfactory.

In spite of all that has been thus far accomplished, the treatment of congenital dislocation of the hip is only satisfactory in so far as it contributes to a functional betterment. Anatomical reduction is rarely permanent.*

Congenital Genu Recurvatum.—This is a rare condition and needs only brief mention. It is not a true dislocation, but more properly a hyperextension of the tibia and fibula upon the femur. The extensor muscles are shortened while the flexors are stretched, and motions in these two directions are correspondingly modified. Associated with this there are frequently other congenital defects such as club foot and absence of the patella. Malposition in utero seems the most probable explanation of the deformity. It is rarely necessary to do more than massage the muscles of the thigh and practise active overcorrection of the deformity, at the same time applying some light apparatus to maintain the corrected position. Forcible correction under an anæsthetic is occasionally necessary.

Dislocation of the Patella.—Displacements of the patella may be associated with knock-knee of congenital origin, or may be caused by lengthening of the patellar tendon. The latter cause gives rise to a condition commonly spoken of as "slipping" patella, but the lengthening of the tendon is undoubtedly a congenital defect.

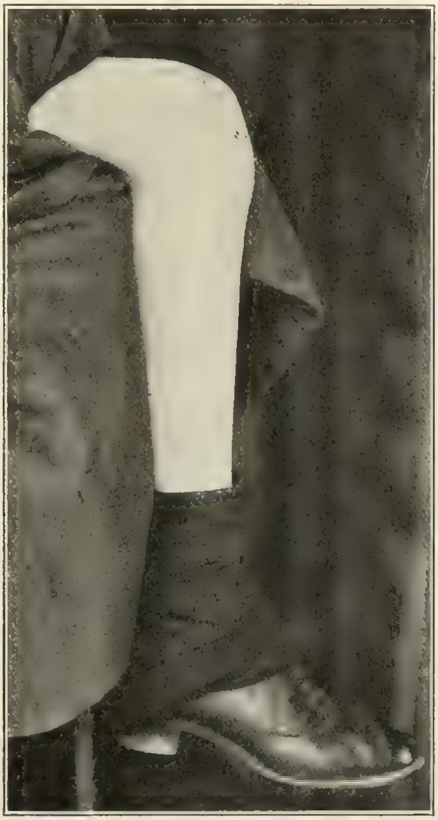

Fig. 551.—After Operation. Side view of Fig. 550. Observe position of patella after transplantation of tibial tubercle. (Original.)

An extreme case of congenital displacement of the patella is shown in Figs. 547, 548, and 549. Only a moderate grade of knock-knee was associated with this condition. The disability resulting from this dislocation was quite extreme, and radical treatment was not undertaken until adult life was established. Discomfort, amounting in many cases to acute suffering, easy fatigue, and a very much restricted radius of activity mark the more severe types of these congenital displacements.

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*This statement is made in view of the tendency to reluxate which quite a number of patients have manifested even in cases where the immediate results were good.

In the "slipping patella" cases there is a sense of instability at the knee-joint which causes the patient constant anxiety. With greater or lesser frequence the patella will slip over the external femoral condyle and the patient may be thrown to the ground; and some manipulation may be necessary in order to restore the patella to its proper place on the femoral condyles. Usually considerable synovitis is produced by these luxations.

Mild grades of knock-knee are not infrequently noted in these cases, thus altering the direction of the pull of the quadriceps upon the tibial tubercle. When the leg is completely extended there is a marked laxity of the joint capsule, and the patella can be pushed over into an extreme position of outward displacement. In these cases, when the leg is extended, the inferior border of the patella rests higher on the femoral condyles than is normal; and it does not descend as far in extreme flexion.

Treatment.—Where the osseous deformity is extreme in its tendency toward knock-knee, it is often necessary to resort to an osteotomy, but many cases may be cured by lesser procedures. Formerly, quilting operations were performed upon the capsule to correct this tendency, but they were attended with failure because the quilted-up portion invariably stretched out. Then the patellar tendon was shortened, but this was not much of an improvement. In the case figured on page 764, the tibial tubercle was transplanted to a position where the pull of the quadriceps would draw the patella over the top of the condyles of the femur, as shown in Figs. 550 and 551.

Goldthwait has also devised an operation, by which the outer half of the patellar tendon is transferred beneath the remainder of the tendon which is left inserted into the tibial tubercle, and is then attached subperiosteally, after the manner of Lange, on the inner face of the tibia at a point similar to that at which the tibial tubercle was transplanted in Fig. 550. This changes the direction of the pull of the quadriceps, and provides for possible failure of the subperiosteal implantation by leaving the inner half of the tendon intact. This operation has been attended with very satisfactory results.

CONGENITAL DISLOCATION OF THE ANKLE.—Most of the congenital dislocations at the ankle, like those at the wrist, are the result of total or partial defects in the development of one or the other of the bones of the leg. The bone most often absent is the fibula, and extreme outward displacement of the foot upon the leg is the result of this absence. It is frequently associated with other congenital defects in the lower extremity. Treatment by the application of an artificial limb, either with or without an amputation in the extreme cases, is all that promises much in the way of function.

TORTICOLLIS.

(CAPUT OBSTIPUM; WRY-NECK.)

By GEORGE D. STEWART, M.D., New York City.

TYPICAL cases of this affection consist of a shortening of the sterno-mastoid muscle, producing a deformity the most prominent feature of which is a twisting or turning of the neck. Secondary involvement of other muscles and tissues may modify, or entirely eliminate, the characteristic deformity; the pathology, however, remaining unchanged. The term torticollis, or wry-neck, expressing as it does only a symptom and explaining nothing of the pathology, should be abolished in favor of a more exact nomenclature. Its application by different writers also varies widely. Thus, by some it is used to include caries of the cervical spine with deformity of the neck—a relation in which wry-neck is manifestly a symptom of a more important underlying disease; while by Keetley and others it is applied only to contraction of the sterno-mastoid. The term, however, has long lineage and even the sanction of present custom, and will be retained and discussed here in the sense defined by Whitman, as follows, viz.: "That in torticollis the distortion is the important disability that demands treatment."

CLASSIFICATION.—The following varieties of torticollis will be described: (*a*) congenital, (*b*) acquired, (*c*) spasmodic, and (*d*) the irregular forms.

The *congenital form* is due to prenatal causes, or to causes operating at the time of birth. It is usually painless and its symptomatology chronic in character.

The *acquired form*, due frequently to infection, to rheumatism, etc., is acute in its early stages, presenting local pain and tenderness, constitutional disturbances, elevated temperature, etc., and passes later into a chronic stage.

The *spasmodic form*, also an acquired variety, begins, as a rule, in clonic spasms of the sterno-mastoid alone, or of this muscle and the trapezius.

The *irregular forms*—paralytic, ocular, mental, etc.—infrequent in occurrence, partly symptomatic, and not clearly defined, are, in accordance with the plan adopted by Whitman, given separate consideration.

CONGENITAL TORTICOLLIS.

Pathology and Etiology.—The most important pathological changes take place in the muscles, principally in the sterno-mastoid, which is permanently contracted and more or less shortened. These changes are an increase of interfibrillary connective tissue, with consequent compression and disappearance of the muscle fibres; in other words, the fibrous tissue increases, the contractile elements lessen. Occasionally this fibrous transformation may be confined to the tendinous extremities, or even to the sternal head alone; in other cases it appears in patches or transverse bands, or it may involve the entire muscle. Further, the process extends to the muscular sheath, a fact which must be remembered in treatment. When the sternal head is involved alone, it feels like a distinct rounded cord; when the whole muscle is implicated, it appears as a firm, fibrous band.

Other muscles—*e.g.*, the trapezius, splenius capitis, and levator anguli scapulæ—may be affected secondarily. Occasionally one of these may be more involved than the sterno-mastoid, but, as a rule, their involvement appears to be a temporary shortening, which is due to forced posture and which disappears when the head is returned to the normal position by dividing or removing the shortened sterno-mastoid.

Secondarily, the deep cervical fascia (Figs. 559 and 560) may be shortened, and indeed all the soft tissues on one side, both anteriorly and posteriorly, may be involved, even to the ligaments, the vessels, and the sheaths of the latter, which are a part of the deep fascia.

Arrest of development of the face on the affected side (facial asymmetry) is found rather frequently; much more rarely do the corresponding half of the cranium and the cerebral hemisphere suffer in the same way.

Lateral curvature of the cervical spine is always present, the convexity of the curve being directed away from the affected side. Sometimes a second compensatory curve develops lower down. According to Keetley, the scoliotic curve of the cervical and upper dorsal regions may be associated with a second compensatory curve in the lower dorsal, and even with a third still lower down in the lumbar region. The latter, however, is not especially important. Rotation of the spine compensating for the lateral distortion of the head, an increase in dorsal kyphosis, and an upward bowing of the clavicle, caused by tension of the sterno-mastoid, may be classed among the minor secondary deformities. Watson Cheyne points out that the curvature seldom leads to permanent alterations in the bones of a character sufficiently marked to prevent, or in any way to interfere with, the restoration of the head to a normal position.

For a long time, particularly since Stromeyer, it has been held that the most frequent cause of congenital torticollis is an injury inflicted on the sterno-mastoid at the time of birth, followed by a hæmatoma of the muscle; in many instances perfect recovery taking place, in others a myositis (fibrous transformation) and ultimate contraction resulting. (It is, of course, recognized that, strictly speaking, torticollis due to causes operating at the time of birth is not congenital.) Of late years, however, there have been many advocates of the theory that congenital torticollis is due rather to prenatal causes, viz., a fixed or constrained position in the uterus for a longer or shorter time before birth.

The arguments of those who accept the latter view and reject the former are well set forth by Whitman as follows: "(1.) Rupture of the muscle in other situations is not followed by myositis. (2.) Myositis and contraction do not follow injury of muscles in animals, unless there is at the same time a pyogenic infection. (Heller.) (3.) Most of the cases of congenital torticollis present no evidence of injury when seen at, or soon after, birth. (4.) Cases of hæmatoma of the sterno-mastoid are not, as a rule, followed by torticollis. (5.) A congenitally shortened sterno-mastoid, due to a constrained position in the uterus, may be ruptured at birth, but the resulting hæmatoma is then merely a complication of a torticollis due to prenatal causes."

These arguments being admitted, there still remain unexplained those cases of torticollis in which practically the sterno-mastoid alone is affected, the other parts being healthy. Surely if these were due to prenatal constraint, other tissues beside the muscle would be involved. Broca (*Journ. des praticiens*, April 8th, 1905) describes this form, which he calls the obstetrical variety of congenital torticollis, as occurring usually on the right side, with a normal spine and with no tenderness on pressure or congestion of cervical ganglia. Further, he points out that two-thirds of the patients are breech presentations, that the damage is never evident at birth but usually two or three weeks later, that in the majority of cases there is recovery without a trace of trouble, and, more important still, that in those which terminate in contracture a myositis ensues which ends in fibrous degeneration of the muscle and its sheath. Friedberg (*Deutsche Zeitschrift für Chirurgie*, Vol. LXI.), in a study of twenty-nine cases from Neuman's Clinic, points out the fact that 55 per cent were breech presentations, and accepts traumatism at birth as the most common etiological factor. Histological examinations were frequently made in his cases, and the invariable findings were interstitial myositis with infiltration and increase of the interfibrillary connective tissue. This author does not deny that muscular atrophy may result from permanent intra-uterine displacement due to lack of space, nor does he regard as untenable Kader's theory that an infectious myositis may sometimes be the primary cause, although bacteria were not found in any of the cases. Kempf (*Zeit. für Chir.*, Vol. 73, Heft. 4–6), from a study of thirty-seven cases, states that the histological findings do not point conclusively to an inflammation of the muscle, but rather to an ischæmia to which he believes the muscle is specially susceptible, both from its exposed situation and from its peculiar vascular relations. This ischæmia, he believes, may affect the muscle during intra-uterine life, at birth following a hæmatoma, or even later in life. Maas (*Zeit. für orthop. Chirurg.*, Vol. XI.) admits in exceptional instances an infectious myositis, but believes that the majority of cases are due to a traumatic muscular necrosis, caused at the time of birth, with secondary substitution of cicatricial connective tissue, as in ischæmic necrosis of muscle elsewhere. The intra-uterine mode of origin he thinks is rare.

To sum up, it would appear that the causative factors may be: (1) prenatal, due to a faulty and constrained position *in utero*, resembling and sometimes occurring with club-foot and similar deformities; or (2), they may be of the nature of a trauma of the sterno-mastoid, inflicted during birth and terminating in a myositis, simple or infectious. The shortening of the fascia may be due to the faulty position *in utero*, or to the faulty position which follows from the damaged muscle. The arrested development in face and brain occurs in the acquired as well as in the congenital form, lessens after an early correction of the deformity, and is therefore probably due to an ischæmia caused by kinking of the artery or, where the fascia is involved, by compression of the arterial sheath. It may even be present at birth without torticollis. When an infectious myositis is the cause, this process may extend to the deep fascia and bring about the same results. The spinal curvatures are, of course, postural. Other causes which have been brought forward to account for certain cases of torticollis are: a defective development of the atlas and others of the cervical vertebræ, and an arrested development of the muscles due to a lesion of the nerves or nerve centres. Cases due to the former cause, if they exist, must be very rare and unimportant; cases of the latter category will be considered under Special Forms. (See p. 804.)

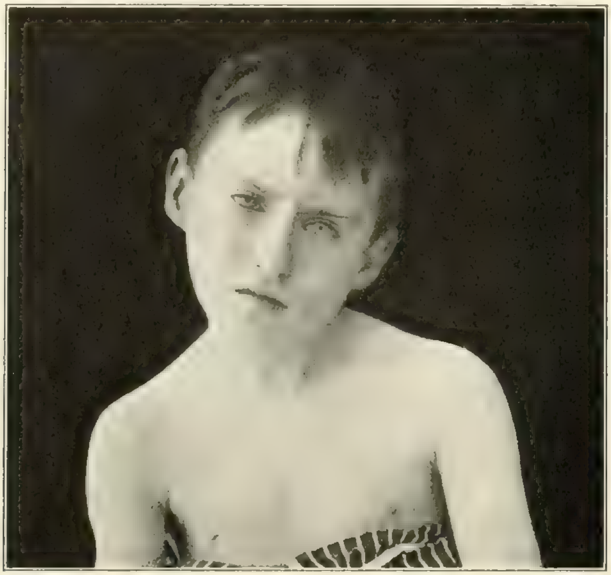


Fig. 552.—Congenital Torticollis of the Left Side. (Collection of Dr. Reginald Sayre.) See also Fig. 553.

Clinical History.—The deformity of Torticollis, or wry-neck, is due to a shortening of the sterno-mastoid and consists of the following displacements: (*a*) The head, as a whole, is tilted toward the contracted side; (*b*) it is displaced forward, the ear on the diseased side approaching the sternum; (*c*) the face is rotated toward the sound side; (*d*) the chin is elevated. (Figs. 552 and 553.) There are many variations from these forms—variations due to implication of other structures. Thus, for example, when the lateral tissues of the neck are principally involved, there is but little rotation and the forward displacement of the head is not marked. When the posterior muscles (trapezius, levator anguli scapulæ, etc.) on one side alone are affected, the head is not displaced so far forward, and the scapula is elevated and tilted; otherwise the deformity is quite typical. Implication of both sterno-mastoids, or of both trapezii, or of the anterior and posterior muscles on both sides of the neck eliminates the rotation and therefore the typical sign of twisted neck. These bilateral combinations are relatively rare. When the particular muscles involved cannot be determined from the deformity, palpation may afford material aid by showing that the affected muscles are rigid, the unaffected remaining flaccid. In long-continued cases, owing to the development of compensatory curvatures in the cervical spinal column, the head, as a whole, is displaced toward the sound shoulder. Motion in certain directions is free; in the direction opposed by the shortened muscles it is, of course, limited.

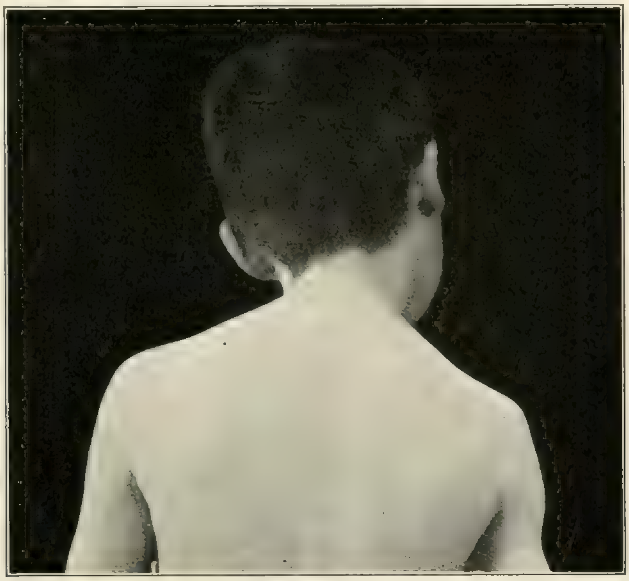


FIG. 553.—Congenital Torticollis of the Left Side, Posterior View, Showing Elevation of the Scapula and Shoulder. (From the collection of Dr. Reginald Sayre.) See also Fig. 552, which represents a front view of the same patient.

In addition to the principal deformity there are other distortions, such as asymmetry of the face, lack of development of the corresponding half of the brain and cranium, and compensatory curvatures of the spine. The asymmetry of the face is supposed to be due to constrained position, lack of blood supply (see under Pathology), restriction of function, and the pulling of the shortened tissues.

It may follow the acquired as well as the congenital form. In well-marked cases the features on the affected sides are smaller; the line of the nose deviates and is not at right angles with the transverse line of the eyes; the nose, corner of the mouth, and even the eyelids on the affected side are drawn downward; and the skull on that side also may show evidence of atrophy. By Witzel the asymmetry of face and skull is regarded as a scoliosis due to dragging of the shortened tissues. (Fig. 554.) The compensatory curvatures of the spine occur primarily in the cervical region; secondarily there may develop a curvature lower down; some rotation, of course, accompanies the curvature; and dorsal kyphosis is observed particularly in the cases of long standing. (Fig. 555.)

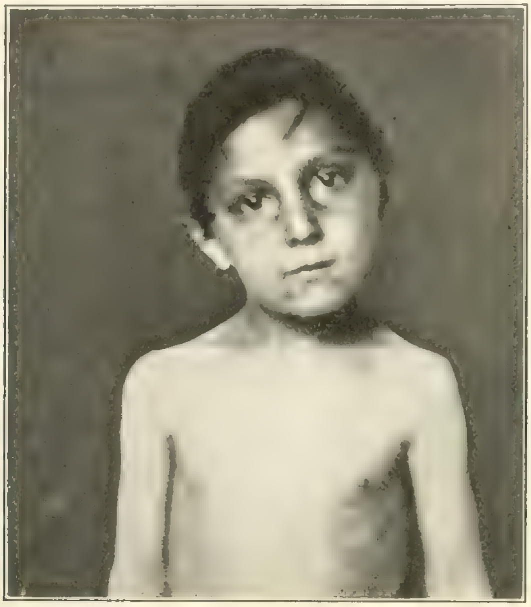


FIG. 554.—Congenital Right-sided Torticollis, Showing Facial Asymmetry. (Collection of Dr. Reginald Sayre.)

Usually the deformity of congenital torticollis is so slight at birth as to escape notice. It may appear in the course of three or four weeks, or not until the child sits, or even later. Occasionally it is extreme at birth, being accompanied by asymmetry of the face and distortion of the skull. As the disease progresses the deformity increases; indeed, all the deformities increase—a fact which emphasizes the importance of early treatment and points emphatically to an increase in the difficulties to be encountered corresponding to the delay in beginning treatment.

In acquired cases the deformity follows rather promptly the onset of the disease.

Diagnosis of Congenital Torticollis.—In congenital torticollis the diagnosis is based on the deformity of the neck and the compensatory deformities, particularly the obliquity and rotation of the shoulders brought about in the attempt of the patient to keep the face as nearly as possible in the perpendicular line; on the contraction and shortening of the muscles as revealed by inspection and palpation; and on the limitation of motion, which is restricted only in the directions controlled by the shortened muscle or muscles. These with the history, the painless character of the affection, and the facial asymmetry when present, serve to differentiate the congenital form of torticollis from Pott's disease of the cervical spine or from a rheumatic or infective process involving the spinal articulations. In the infant a suspected congenital torticollis may be made more apparent by drawing the arm downward on the suspected side, at the same time rotating the head toward the opposite side, by which means the shortened muscle is made prominent. (Whitman.)

Prognosis.—In congenital torticollis, and also in the chronic form of acquired torticollis, the prognosis depends on the success of the surgical measures employed. A complete permanent cure may be obtained, in a majority of all cases the head recovering its normal range of motion, the scoliosis disappearing, and the asymmetry becoming less and less.

Treatment.—If the sterno-mastoid has been ruptured at birth and is the seat of a hæmatoma, care should be exercised to prevent the occurrence of torticollis. Absorption of the clot should be promoted by massage with the use of ointments or of hot fomentations, and shortening of the muscle should be prevented by placing the head in suitable postures. If slight deformity has occurred, either with or without discoverable hæmatoma, it may be overcome by drawing downward on the arm of the affected side and turning the face forcibly toward the same side—that is, in the direction which will put on the stretch the contracted muscle. This should be repeated several times daily, massage of the stretched muscle being employed at the same time and every possible advantage being taken of posture, both in bed and in the nurse's arms. When the deformity has persisted for any length of time and is at all well marked,—when the muscle is shortened one inch or more (Whitman),—attempts at stretching, either by manipulation, or by extension, or by the use of apparatus, are absolutely use-

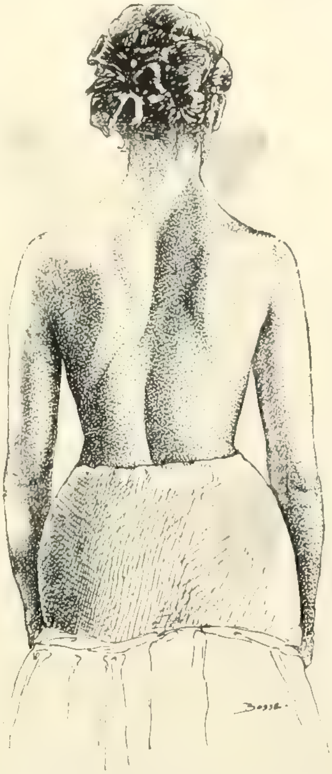


FIG. 555.—A Case of Torticollis Showing Compensatory (Primary and Secondary) Spinal Curvatures. (From the collection of Dr. Reginald Sayre.)

less, and resort must be made to operative measures. In the operative treatment two points of importance call for consideration: first, to rectify the distortion, by cutting or by manipulation; second, to maintain the head in a suitable position by some form of apparatus. The operations recommended are: first, subcutaneous tenotomy; second, open division of muscles and fascia, and of all resisting structures.

SUBCUTANEOUS TENOTOMY.—This operation has not a wide range of applicability, and should be reserved for those cases in which the deformity is slight and confined chiefly to the sternal head of the sterno-mastoid, and for most of those occurring in girls—cases, therefore, in which æsthetic considerations play an important part. The muscle should be placed on the stretch and the tenotome, entered along the inner side of the sternal head, about one inch above its origin, should be passed beneath the muscle, dividing it from within outward. Forcible manipulation may succeed in correcting any remaining slight contraction of the sheath or fascia.

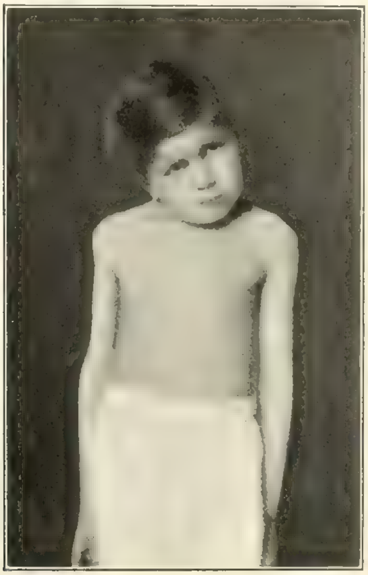


FIG. 556.

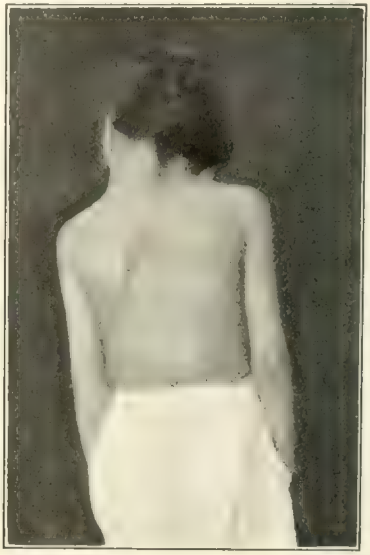


FIG. 557.

FIG. 556.—Congenital Torticollis with Extra Cervical Rib. Front view. (From the collection of Dr. Reginald Sayre.)

FIG. 557.—Congenital Torticollis, with Extra Cervical Rib. View from behind. (From the collection of Dr. Reginald Sayre.)

THE OPEN OPERATION.—In nearly every case, in order to overcome the deformity, it is necessary to divide both heads of the sterno-mastoid and the muscular sheath. Other muscles may be involved secondarily—*e.g.*, the trapezius, the splenius, etc.—but, as a rule, these yield to forcible manipulation after the more resisting structures have been divided. For the open treatment of the muscle and its sheath, various incisions have been employed, and it is only fair to say that most of them do not adequately expose the parts. Particularly is this true of the vertical incisions which, according to the recommendations, should be made midway between the two heads in the line of the muscle or along the posterior border. Transverse incisions, on the other hand, while they give a better exposure, are liable to become puckered, particularly if the muscle division is made in the same plane as the skin. This can be overcome by dividing the muscle on a higher level. (See Fig. 558.) Chiene employs a curved incision, which starts about one-quarter of an inch behind the anterior border of the muscle, and an inch and a half above the clavicle, then passes backward and downward over the anterior third of the posterior triangle, and finally curves downward and forward over the clavicle to a point about opposite the centre of the sterno-mastoid. When this flap is turned forward, the whole outer aspect of the muscle and both borders are exposed. If this incision is objected to on account of its extent, a modification of Kocher's incision for thyroidectomy is recommended by the same author. An effective and well-concealed incision is one placed parallel to and just above the clavicle. That the skin and muscle incisions may not be superimposed, the

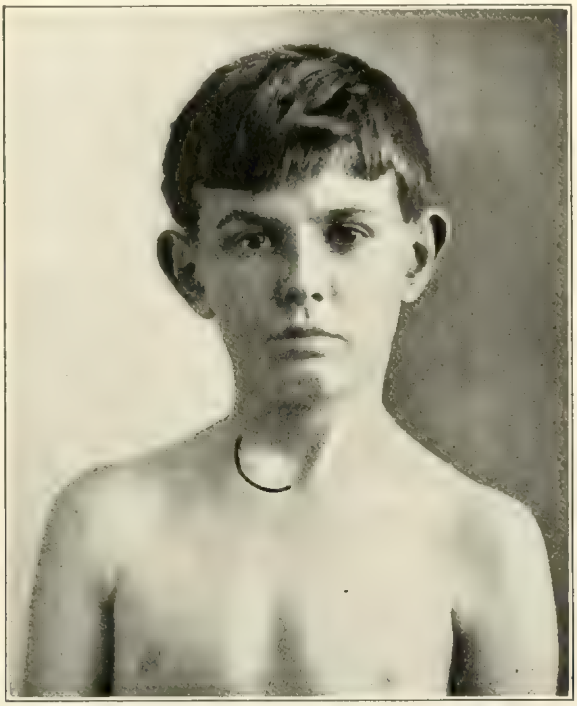
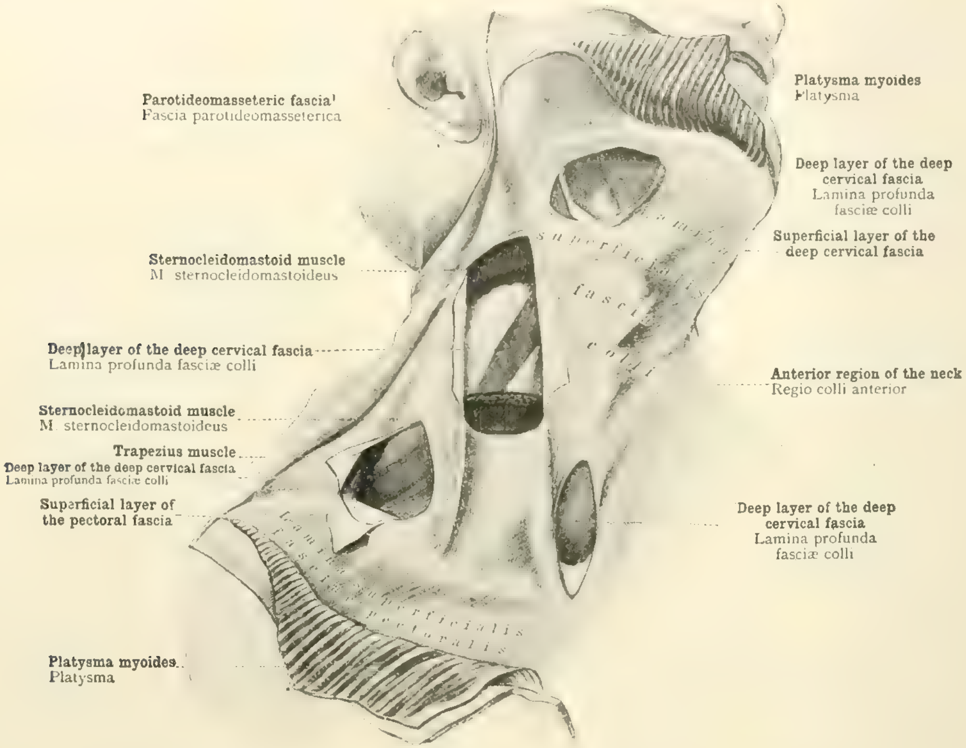


FIG. 558.—Congenital Torticollis. (Author's case.) Open division of sterno-mastoid through a curved incision over the clavicle. Muscle division was made at a high level by retracting the upper edge of the incision. No puckering of the skin followed.

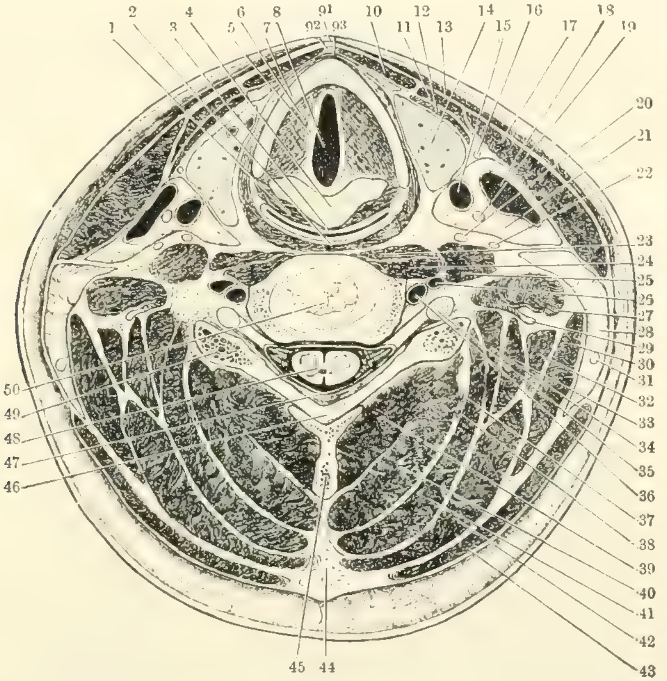
skin is drawn slightly upward and divided by cutting upon the clavicle. When the skin is released, the position of this incision is transferred to a still lower level. Through this incision, aided by retraction of the upper edge, the muscle may be adequately bared. After the muscle has been exposed, the finger or a grooved director should be passed beneath it from posterior to anterior border, and then the entire muscle should be completely divided either transversely or, according to Chiene, obliquely from the anterior border upward and backward. When this has been done, the neck should be put on the stretch and all resisting structures, whether muscular or fascial, should be divided. For this purpose, it may be necessary to increase the length of the incision. The deep cervical fascia is particularly liable to resist attempts at readjustment, and it is sometimes necessary even to divide the sheath of the carotid vessels, a distinctly difficult procedure. (See Figs. 559 and 560.) Forcible stretching, both by lateral bending and by rotation, should be kept up during the operation, as it enables one to locate the resisting structures and sometimes to accomplish, with a mere nick of the knife, divisions that would otherwise be difficult.


Parotideomasseteric fascia[1]
Fascia parotideomasseterica
Platysma myoides
Platysma
Deep layer of the deep cervical fascia
Lamina profunda fasciæ colli
Superficial layer of the deep cervical fascia
lamina superficialis fasciæ colli
Sternocleidomastoid muscle
M. sternocleidomastoideus
Deep layer of the deep cervical fascia
Lamina profunda fasciæ colli
Anterior region of the neck
Regio colli anterior
Sternocleidomastoid muscle
M. sternocleidomastoideus
Trapezius muscle
Deep layer of the deep cervical fascia
Lamina profunda fasciæ colli
Superficial layer of the pectoral fascia
lamina fasciæ superficialis pectoralis
Deep layer of the deep cervical fascia
Lamina profunda fasciæ colli
Platysma myoides
Platysma

[1] In England, the portion of the deep cervical fascia covering the parotid gland is usually distinguished the *parotid fascia*; that covering the masseter muscle, as the *masseteric fascia*.—Tr.

Fig. 559.—Dissection of the Right Side of the Neck, Showing the Deep Cervical Fascia at Several Points. (From Toldt's "Atlas of Human Anatomy," London, 1904.)

Care should be taken to avoid wounding the external and internal jugular veins. The former, as a rule, can be seen; if not apparent, it may be made so by pressing backward with the finger above the clavicle and just behind the clavicular origin of the muscle. The deep or internal jugular is separated from the muscle by the deep fascia, and with reasonable care it can be avoided. Wounds of this vessel made during tenotomy have resulted fatally. Keetley recommends, for the control of a punctured wound of the internal jugular, a com-



1. Crico-thyroid muscle.
2. Inferior constrictor muscle.
3. Pharynx.
4. Cricoid cartilage.
5. Vocal cord.
6. Thyro-arytenoid muscle.
7. Thyroid cartilage.
8. Glottis.
9. Layers of deep cervical fascia.
10. Sterno-hyoid muscle.
11. Omohyoid muscle.
12. Sterno-thyroid muscle.
13. Cervical fascia.
14. Thyroid body.
15. Common carotid artery.
16. Descendens hypoglossi nerve.
17. Sterno-mastoid muscle.
18. Internal jugular vein.
19. Pneumogastric nerve.
20. Sympathetic nerve.
21. Carotid sheath.
22. Phrenic nerve.
23. Longus colli muscle.
24. Rectus capitis anticus major.
25. Scalenus anticus.
26. Vertebral vein.
27. Scalenus medius.
28. Posterior triangle.
29. Scalenus posticus.
30. Levator anguli scapulæ.
31. Spinal accessory nerve.
32. Splenius colli.
33. Transversalis crevicis.
34. Trachelo-mastoid.
35. Spinal nerve.
36. Vertebral artery.
37. Profunda cervicis vein.
38. Profunda cervicis artery.
39. Multifidus spinæ.
40. Semispinalis colli.
41. Complexus.
42. Splenius capitis.
43. Trapezius.
44. Ligamentum nuchæ.
45. Spine of fourth cervical vertebra.
46. Lamina of fifth cervical vertebra.
47. Dura mater.
48. Spinal cord.
49. Transverse process.
50. Disc between fourth and fifth cervical vertebræ.

Fig. 560.—Transverse Section of the Neck Between the Fourth and Fifth Cervical Vertebræ, Showing the Deep Cervical Fascia, particularly in relation to the sterno-mastoid and the sheath of the vessels. (Cunningham.)

press soaked in bichloride solution, but a lateral or partial ligature is more reliable. Bradford and Lovett relate a case in which they ligated the vessel in its continuity for a wound, no ill results following.

The muscle has also been divided in other parts of its course, particularly near its mastoid attachment and in the lower third. In these situations, however, the muscle is thicker and the wound is more exposed—conditions distinctly disadvantageous. When there is great deformity, particularly when there is marked involvement of the posterior muscles—*i.e.*, posterior torticollis,—it may be necessary to divide these. Division can be performed by making an incision backward from the anterior border of the mastoid process, at such a level that it will be concealed by the hair, care being taken to avoid the facial nerve. Bradford and Lovett regard most of these muscles as too deeply placed and too extensively connected for tenotomy, and content themselves by dividing the trapezius and the outer bands of the anterior scalenus; they overcome the remainder by force. Through the above incision, however, it is possible to divide without danger practically all of the lateral and posterior muscles attached to the occipital bone—the trapezius, splenius capitis, complexus, and the trachelo-mastoid. The deepest of these—the anterior and lateral recti—together with those muscles which are not attached to the occipital bone, but act only on the upper segment of the spine, may then be overcome by manipulation.

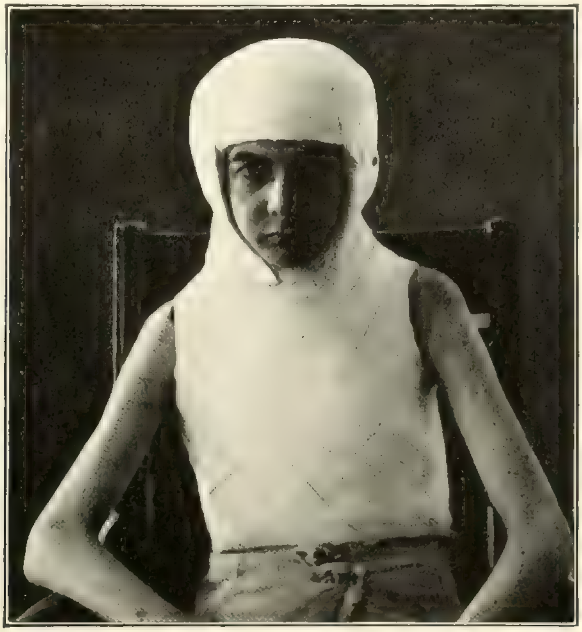


Fig. 561.—Plaster Helmet, a Retention Dressing for Torticollis. By sawing a band out of the plaster around the neck a readjustment may be made in the relations between the two parts.

Forcible attempts at correction, continued throughout the operation, enable one to decide just which tissues may be stretched and which should be cut.

The Mikulicz operation for congenital torticollis, which consists of a partial or complete extirpation of the sterno-mastoid, has been warmly advocated by some, and vigorously condemned by others. The arguments advanced for the operation by Hoffa,* Stumme,† and others are a complete restoration of function, and the fact that usually no further orthopedic treatment is needed. The arguments against the operation are that it is needlessly radical and conspicuously mutilating. Besides, as pointed out by Lorenz, it does not in any way relieve other muscles involved, either those which act on the head and produce the *caput obstipum* or those which are attached to the cervical spine and produce the *collum obstipum*.

Maintenance of Reduction.—After all resisting structures have been divided the head should be placed in the overcorrected position and held there by some form of apparatus. The very best form of the latter is the plaster helmet, (Fig. 561), beneath which there should be a copious supply of cotton, particularly around the neck. The helmet will have to be removed or else it will be necessary to open a window in it over the incision at the proper time for removing the stitches and dressing the wound. After the latter has healed, the helmet may be left on for from four to eight weeks or even longer, depending on the severity of the original deformity and the success which has attended the operative part of the treatment. During this period, by cutting a ring out of the plaster helmet where it surrounds the neck, further correction of the deformity may be made from time to time by a readjustment in the relations of the two portions of the helmet. Until the wound has completely healed, removable plaster splints may be employed. These are applied at the time of operation, are cut off as soon as they have dried, and being reapplied are held in position by bandages or adhesive straps. Chiene states that in mild cases it is only necessary to place the patients in bed, flat on the back, for ten days, the head being supported with sand bags. In severer forms he recommends the employment, for three weeks, of extension of the head by means of a weight and pulley and head-stall. It is doubtful if the former plan is as comfortable, and it is certainly not as effective, as the helmet, while the latter (*i.e.*, the use of extension) cannot compare with the helmet in efficiency, since the head can only be extended in a straight line, and overcorrection, either in the direction of rotation or in that of lateral displacement, is not possible. To overcome the latter ob-

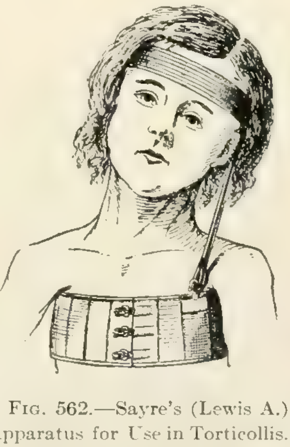


FIG. 562.—Sayre's (Lewis A.) Apparatus for Use in Torticollis. This is applied after division of the sterno-mastoid muscle. (After Cheyne and Burghard.)

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* Centralblatt für Chirurgie, 27, 1900.

† Zeit. für orthopaedische Chir., Bd. ix., Heft 3.

jection, and where the helmet is found cumbrous, Bradford and Lovett recommend securing the patient on a gas-pipe frame and overcorrecting each of the deformities by light weights and pulleys attached to the proper points on the patient's head by means of adhesive plaster. Another point in favor of the helmet is that its use does not confine the patient to bed.

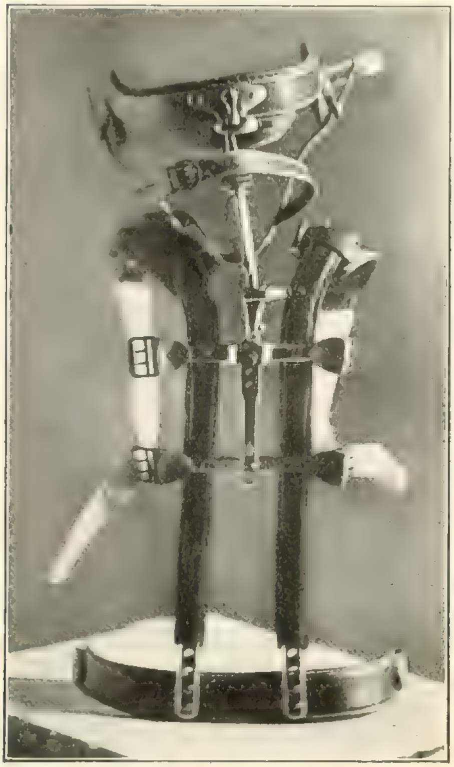

FIG. 563.—Sayre's (Dr. Reginald) Retention Apparatus for Torticollis.

If, after the splint has been removed, it be found that the deformity has been overcome, it will be necessary, in order to prevent its return, to institute systematic exercise, to employ massage, and constantly to take advantage of posture. By means of passive motion the head should, at least once each day, be overcorrected to the limit, and in some cases it will be of advantage to suspend the patient by means of the head-stall and tripod used in the application of the plaster jacket.

When the deformity has not been thoroughly overcome, the use of the plaster helmet may be continued, the deformity being corrected more and more by sawing the upper part of the helmet from the lower and changing the relation of one to the other, as already described.

Other lighter though less efficient forms of apparatus, applicable to minor cases without operation and to slight deformities remaining after operation, are the following:—The Sayre apparatus, which comprises a band around the head, another around the chest, the two united by one or more elastic bands applied at the points of greatest advantage (Fig. 562); the jury mast, which may be supported either by a plaster jacket or by posterior padded braces held to the body by means of straps (Fig. 563); and the apparatus of Buckminster Brown (Figs. 573, 574, and 575), which consists

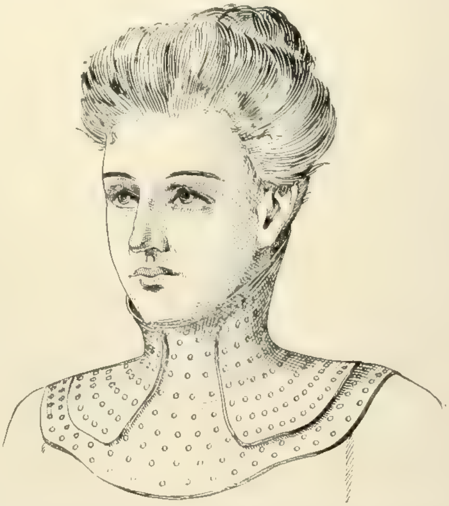

FIG. 564.—Apparatus for the After-treatment of Torticollis. (After Tillmanns.)

of a suitably covered wire collar around the neck, a plate under the chin arranged to overcome rotation, and a pad behind the ear to overcome the lateral inclination of the head, the whole being attached to a ring which rests on the shoulders and which is connected to arms that pass down the back and are fastened to the body by means of straps. An even simpler dressing is that of Little, which consists of a band of adhesive plaster passed around the chest and another passed around the head, the two being united in the way which best overcomes the deformity and gives the firmest support—as by means of bandages or rubber bands.

ACQUIRED TORTICOLLIS.

Acquired torticollis, as already stated, is an affection due either to an injury or to disease of some of the structures of the neck, which produces irritation of the peripheral nerves, active contraction of one or more of the muscles of the neck, and—as a result of such contraction—the characteristic deformity or some variation therefrom. (Fig. 565.) It is, as a rule, painful, while congenital torticollis is painless—a difference due, in part at least, to the fact that the former is usually observed in the acute stage, the latter in the chronic. Acquired torticollis may be acute

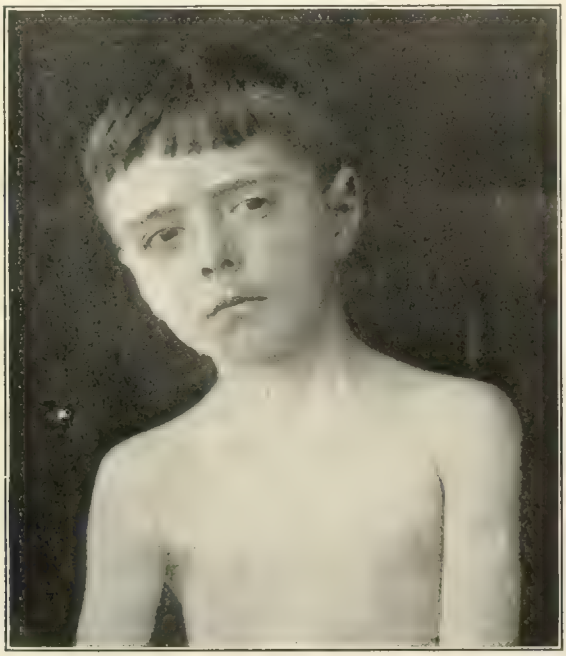

Fig. 565.—Torticollis Acquired from Inflamed Cervical Lymph Nodes. (Author's case.)

or chronic. In the acute form the causative factors are active, the muscular contractions are tonic, and there is pain; in the chronic form the inflammation, or the disturbance caused by the injury, has subsided, the irritation of the nerves has disappeared, and the deformity has become permanent, due to a shortening of the muscles, fasciæ, or some of the other structures of the neck. Acquired torticollis also embraces the irregular forms (paralytic, ocular, psychical) and the spasmodic variety, but the latter bears little resemblance to the other forms and will, therefore, with the irregular forms, receive separate consideration.

Etiology of Acute Torticollis.—A majority of the cases are spastic and are produced by infection followed by inflammation affecting one or more of the structures of the neck. In fifty-five of two hundred and twelve cases (reported by Whitman from the Records of the Hospital for Ruptured and Crippled), the cervical lymph nodes were suppurating or enlarged. According to Chiene an ordinary septic involvement of these nodes is more likely to cause torticollis than a tuberculous invasion. Infection of the mucous membrane of the pharynx or naso-pharynx, such as occurs in the course of a tonsillitis or a pharyngitis, bears often an etiological relation to torticollis, and scarlet fever, diphtheria, and measles have similar relations probably because of their local effects on the same membrane. Other inflammations which have been noted as causative are cellulitis of the neck, otitis, mastoiditis, and parotitis.

Injury of the neck, whether direct or indirect, such as strains, hæmatomata, etc., are important causative factors; they produce, according to Whitman's table, thirty-five cases out of two hundred and twelve. It must be observed that the vast majority of such injuries recover without producing torticollis. Rarely, a dislocation of the upper cervical vertebra may cause torticollis.

Rheumatism of the muscle following exposure to cold—the ordinary stiff neck—produces a relatively large proportion of mild acute cases, which soon yield to treatment. In these cases the action on the muscle is probably direct.

Sometimes the affection is preceded by earache, toothache, neuralgia of the spinal accessory, brachial plexus, etc. Such a sequence can probably be explained on anatomical grounds, viz., by the nerve communications in this region. Constitutional conditions which have been noted as causative in a small number of cases in the tables referred to, are syphilis, vaccinia, rachitis, and malaria. The effects of the first two are probably local, syphilis producing gummatous changes in the muscle, vaccinia a local irritation of the superficial cervical nerves; even the influence of rachitis might be explained on local grounds. It is difficult, however, to trace the relationship of malaria.

Contracting cicatrices, such as follow burns, produce torticollis in the same way as contraction of fibrous tissue following inflammation or injury produces deformities in other parts of the body.

Cervical Pott's disease is considered by some authors to be a cause of torticollis. In such a case the wry-neck should be regarded as merely a symptom.

A distortion of the neck somewhat resembling torticollis may be compensatory following a primary curve in the dorsal region.

A small proportion of cases occur in combination with chorea, epilepsy, hysteria, meningitis, hemiplegia, etc.

In many cases, it must be remembered, the patients are of a neurotic temperament—a predisposing condition which explains why similar causes, operating in different subjects, produce only a limited number of cases of torticollis.

Other forms which only need to be mentioned are the "voluntary-habit torticollis," which is physiological, and the "occupation torticollis," in which the patient is compelled habitually to overuse one sterno-mastoid, disturbing the balance. These varieties are akin to occupation spasm.

Pathology.—The pathology of the acute cases is largely the pathology of the underlying cause. When an inflammation involves the muscle, its effect is in a measure direct. More remote causes produce a reflex spasm of the muscles by producing an irritation of the peripheral nerves, and this is particularly so in cases produced by irritation of the mucous membrane. In the chronic stage, the pathology is the same as that found in the congenital variety; that is, there is a shortening of the muscles and fascia due to the contracting of the fibrous tissue which has replaced both of these structures.

Symptomatology.—The most important symptom of a typical case of acute torticollis is a distortion of the neck similar to that produced in congenital torticollis by shortening of the sterno-mastoid muscle. In the acute form, however, there is likely to be a wider involvement of muscles than in the congenital. To be considered are: The number and grouping of the muscles involved, the variety and degree of the underlying inflammation or disease, and the onset, course, and duration of the affection.

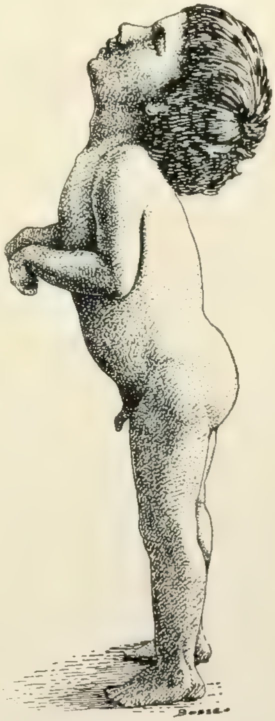

FIG. 566.—A Case of Retrocollis Due to Low Dorsal Pott's Disease. (Copied from a photograph belonging to the collection of Dr. Reginald Sayre.)

Deformity.—The most frequent combination of muscles is the sterno-mastoid with the trapezius of the same side, the latter accentuating the deformity produced by the former. Less frequently the posterior muscles of one side are involved alone, in which case rotation is marked, but there is more backward displacement of the head. Rarer combinations are, bilateral involvement of the sterno-mastoids, of the trapezii, or of both anterior and posterior groups. Although several groups may be involved, usually one muscle, or one group, is affected to a greater degree than the others. According to some, the small muscles acting directly on the upper portion of the cervical spine may tilt the head forward without rotation, and with little lateral displacement, the deformity produced resembling that found in cervical Pott's disease.

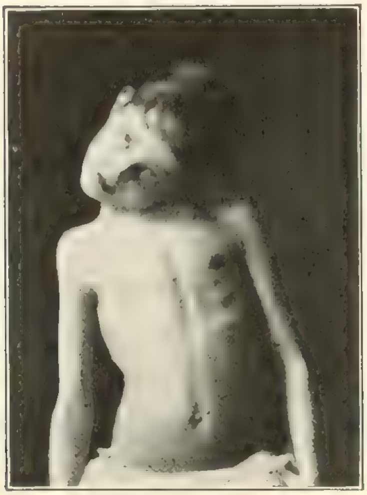

FIG. 567.—Torticollis, a Symptom of Tuberculous Disease of the Second Cervical Vertebra. (From the collection of Dr. Reginald Sayre.)

Pain is a constant symptom. It varies in intensity for obvious reasons, and is aggravated by any attempt to stretch the muscles or to correct the deformity. The patients are irritable, partly as a result of the discomfort, and partly by reason of the underlying cause, and many of them prefer sleeping in a chair to attempting the almost hopeless task of composing themselves comfortably in bed.

The *onset* of the disease may be gradual or sudden; its duration varies largely in accordance with the cause. In mild cases, particularly the rheumatic, or in those due to slight injury, the duration may be short. In the severer forms, particularly those dependent on inflammatory processes, the disease lasts for weeks, even for months, and after the subsidence of the pain and spasm there remains deformity due to the shortening of muscles and fascia. Even in the severe forms the course of the disease may be modified by appropriate treatment.

Diagnosis.—Here the diagnosis is based on the usually sudden onset, the deformity, the apparent spasm of muscle or muscles, the freedom of motion in all directions except those controlled by the affected muscles, and the presence of pain, which is increased by tension and lessened by relaxation. The condition must be carefully differentiated from Pott's disease, which is characterized by a slow onset preceded by stiffness, and by pain which is lessened by extending the spine, but is increased by any attempt at rotation, by jarring, or by pressing the head downward. In Pott's disease, too, the distortion is not typical, and there

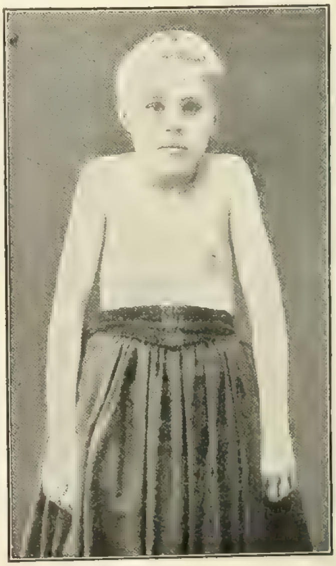

FIG. 568.—Bilateral Contraction of the Sterno-mastoids and Trapezii Muscles. (From Whitman's "Orthopædic Surgery," Lea Bros. & Company, Philadelphia, 1901.)

may be an evident deformity and tenderness of the vertebræ. Rheumatic affections of the atlo-axoid joint, or an arthritis due to an acute infection, may be mistaken for an acute torticollis, and the differentiation will depend on the history of the case and on the fact that, in the latter, the deformity is not typical, the muscles on all sides uniting to restrict the movements. The use of the *x*-ray will be found most valuable in diagnosis.

A case of acute torticollis, which has subsided unobserved into the chronic stage, can often not be differentiated from the congenital form.

Prognosis.—In acute torticollis the prognosis depends on the treatment of the underlying cause. For example, when the condition is due to suppurating lymph nodes it will disappear with proper drainage and healing of these structures; ordinary stiff neck due to rheumatism commonly disappears in a few days; now and then neglected cases due to muscular inflammation—so-called idiopathic wry-neck—may become chronic.

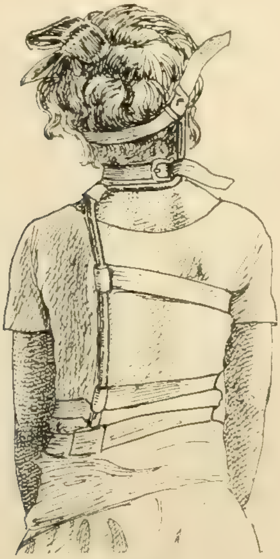

FIG. 569.

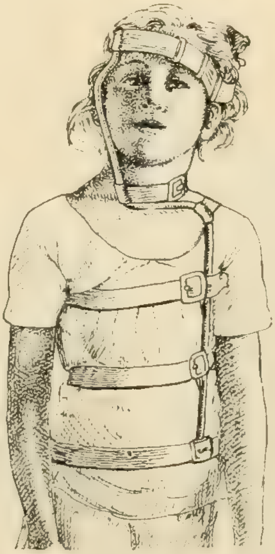

FIG. 570.

FIG. 569.—Bratz's Retention Splint for Torticollis; Posterior View.
FIG. 570.—Bratz's Retention Splint for Torticollis; Anterior View.

Treatment.—In the ordinary "stiff neck" the most effective treatment is rest, with the application of liniments, hot fomentations, etc. For the purpose of limiting motion a collar made of a copious supply of cotton wound around the neck, and covered with several thicknesses of adhesive plaster, is effective. Instead of the adhesive plaster, splints of moulded felt or other similar material may be employed. (Fig. 564.) If there is a rheumatic element, salicylates should be administered. If the pain is severe, particularly in cases apparently due to the effects of cold, a Dover's powder may be given, and some form of local sedative may be applied.

In cases which are characterized by acute spasms the first consideration is to remove the cause. If there are suppurating lymph nodes, these should be drained; if the nodes are the seat of tuberculosis, proper hygienic measures should be adopted; if the irritation comes from the pharyngeal mucous membrane, proper measures should be taken to restore this to a normal condition. To relieve pain and to prevent the occurrence of deformity or to arrest its increase if it is already present, the head should be supported by a helmet, a jury mast, or some form of collar. After the acute symptoms have disappeared, minor degrees of deformity may be relieved by manipulation, by suitable support, and by hygenic measures. After the deformity has become permanent—that is, in the chronic form of acquired torticollis—the treatment is the same as for the congenital variety.

SPASMODIC TORTICOLLIS.

Spasmodic torticollis, or spasmodic wry-neck, is a form of convulsive spasm of one or more of the muscles that move the head upon the trunk. Because it is frequently confined to the sterno-mastoid and trapezius muscles, that are chiefly innervated by the eleventh or spinal accessory nerve, it is often referred to as "spinal accessory spasm." Where one or both of the muscles mentioned are involved, the most characteristic symptom is a sudden rotation of the face to the opposite side—hence the name "spasmodic torticollis."

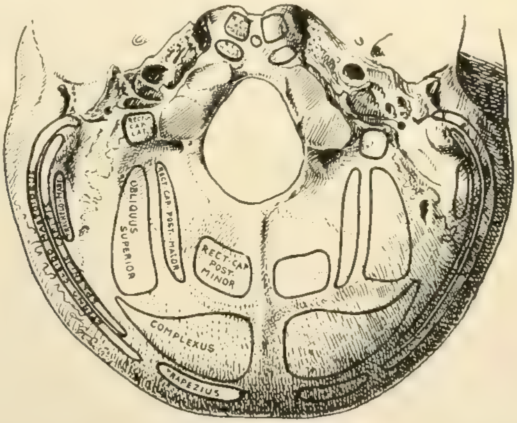

FIG. 571.—Inferior Surface of Occipital and Temporal Bones, with the Muscular Attachments.

Before proceeding to discuss this subject I think it will be of use to give a brief review of the anatomy of some of the structures concerned. For more complete information on this division of the subject the reader is referred to the text-books on anatomy.

Anatomy.—All of the *muscles* concerned in the production of spasmodic torticollis, except one—the inferior oblique—are attached to the inferior surfaces of the occipital and temporal bones. (Fig. 571.) For convenience it is proposed to describe briefly the more important of these muscles, the inferior surfaces of the occipital and temporal bones being taken as a starting-point, and information being supplied in regard to their attachments, action, and nerve supply.

The *sterno-cleido-mastoid muscle* is attached to the mastoid process by means of a thick tendon, while a thinner part constitutes its attachment to the outer half of the superior curved line of the occipital bone. Running downward, forward, and inward, it is attached by two heads—the inner, a thick, rounded fasciculus, to the anterior and upper part of the first piece of the sternum; the outer, much wider as a rule, to the inner third of the clavicle. (Fig. 576.)

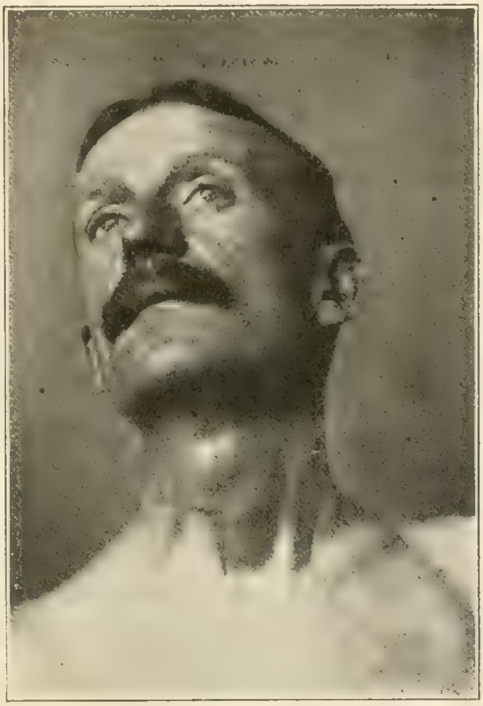

Fig. 572.—Spasmodic Torticollis, One Month after Excision of the Spinal Accessory. The spasms had not entirely ceased, after the wound had healed, but were controlled sufficiently to permit the taking of a photograph. A few fibres of the platysma are evident in the picture. (Author's case.)

The *trapezius muscle* arises from the inner third of the superior curved line of the occipital bone, the external occipital protuberance, the ligamentum nuchæ, the spinous processes of the seventh cervical and all the dorsal vertebræ, and is inserted into the outer third of the posterior surface of the clavicle, the inner border of the acromion process, and the superior border of the spine of the scapula. The occipital and upper cervical fibres, which run downward, forward, and outward for insertion into the clavicle, are the only ones which need to be considered here, as these fibres alone can have much influence in the production of torticollis.

The *splenius muscle* arises from the lower half of the ligamentum nuchæ and from the spinous processes of the last cervical and the upper six dorsal vertebræ. Running upward it divides into the *splenius capitis* and the *splenius colli*. The former, the splenius capitis (the only part which is important in this connection) is inserted into the mastoid process and the occipital bone beneath the sternomastoid.

The *trachelo-mastoid muscle* arises from the transverse processes of the five or six upper dorsal, and from the articular processes of the three or four lower cervical vertebræ and is inserted into the mastoid process beneath the splenius capitis.

The *rectus capitis posticus major muscle* arises from the spinous process of the axis, and is inserted into the outer part of the inferior curved line of the occipital bone and the surface immediately below it.

The *obliquus capitis inferior muscle*, as already mentioned, is not attached to the base of the skull. It arises from the spinous process of the axis and is inserted into the transverse process of the atlas. Keen believes it to be one of the most important of the rotators because of its favorable leverage.

The other muscles are the following: the *complexus*, attached above to the innermost depression between the two curved lines of the occipital bone, below to the articular processes of the lower cervical and the transverse processes of the upper dorsal; the *rectus capitis posticus minor*, which lies parallel with and internal to the rectus capitis posticus major, and is attached, above, to the surface of the skull beneath the inferior curved line of the occipital bone, and below to the posterior arch of the atlas; the *superior oblique*, which is attached, above, to the occipital bone, between the two curved lines external to the complexus, and below to the transverse process of the atlas; the *rectus capitis lateralis*, which unites the jugular process of the occipital bone with the transverse process of the atlas; the *rectus capitis anticus major*, which joins the basilar process of the occipital bone to the anterior surfaces of the transverse processes of the middle three or four cervical vertebræ; and the *rectus capitis anticus minor*, which connects the basilar process of the occipital bone with the anterior surface of the lateral mass of the atlas.

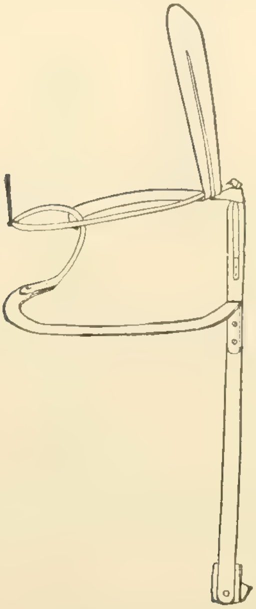

FIG. 573.—Buckminster Brown's Splint for Control of Torticollis.

Action.—"Flexion and extension of the head take place chiefly at the occipito-atlantoid articulation; lateral movement and rotation at the atlanto-axial joint." (Cunningham.) The actions of the muscles on the head and neck are exceedingly complex, and authorities do not agree as to all points. It may facilitate our understanding to inquire what are the changes in position produced by the sterno-mastoid when this alone is the seat of spasm—the most frequent form of spasmodic torticollis,—and then to group the muscles in accordance with the extent to which they promote or retard each phase of the deformity.

Sterno-mastoid muscles.—Authorities are not agreed as to the action of these muscles when working as a pair, some stating that they extend, others that they flex, the head. The view of the writer is that their action will depend on the position of the head when these muscles begin to act; that is, that after the head has been carried forward beyond a certain point by other muscles—*e.g.*, the depressors and elevators of the hyoid bone—the sterno-mastoids will flex the head; but that, if the action of the other muscles has been to carry the head backward for some distance, the sterno-mastoids will then act as extensors. When, however, one muscle alone is acting, it is practically agreed that the following changes in position take place: (*a*) The ear is brought down to the shoulder, or, more correctly speaking, toward the clavicle, of the same side—*lateral bending;* (*b*) the face is turned to the opposite side—*rotation ;* (*c*) the chin is elevated—*extension at the occipito-atloid joint;* (*d*) the whole head is displaced forward and the neck is apparently shortened—*flexion of the cervical spine.*

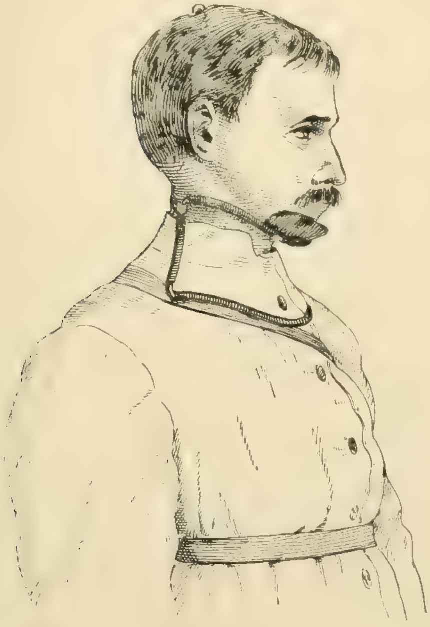

FIG. 574.

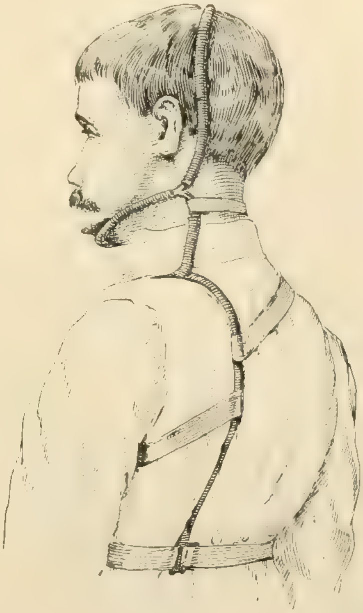

FIG. 575.

FIG. 574.—Buckminster Brown's Splint Applied; Front View.
FIG. 575.—Buckminster Brown's Splint Applied; Posterior View.

Lateral bending will be strongly assisted by the upper fibres of the trapezius, by the splenius capitis, by the trachelo-mastoid, and, to a lesser and varying degree, by all the other muscles of the same side; it will be markedly opposed by the sterno-mastoid, by the trapezius, and indeed by all the muscles of the opposite side.

Rotation will be increased by the upper fibres of the trapezius of the same side, and by the posterior rotators, particularly the splenius capitis, the rectus

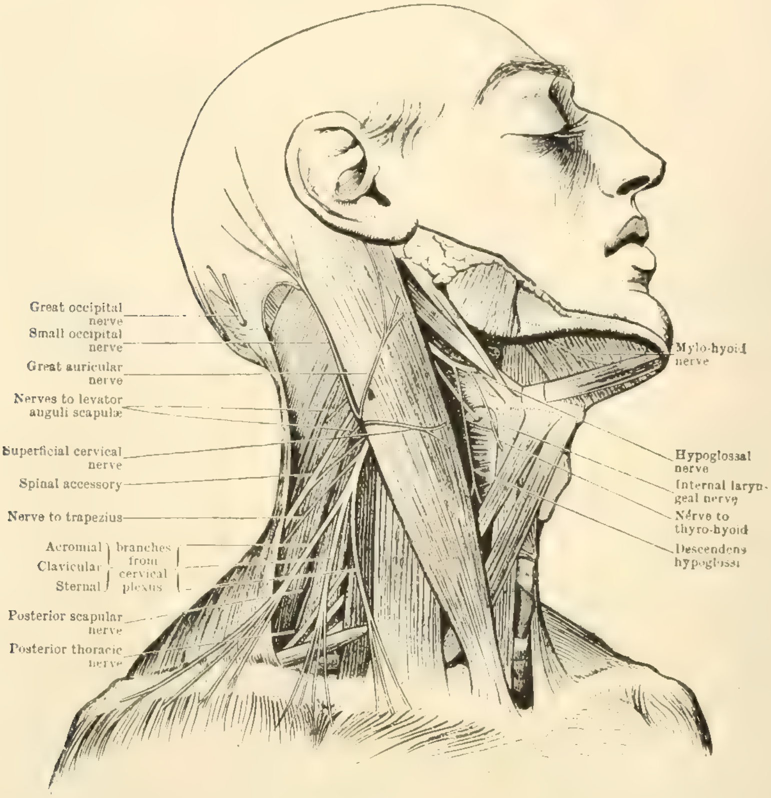

Fig. 576.—The Triangles of the Neck, with Reference mainly to the Spinal Accessory Nerve. (Cunningham.)

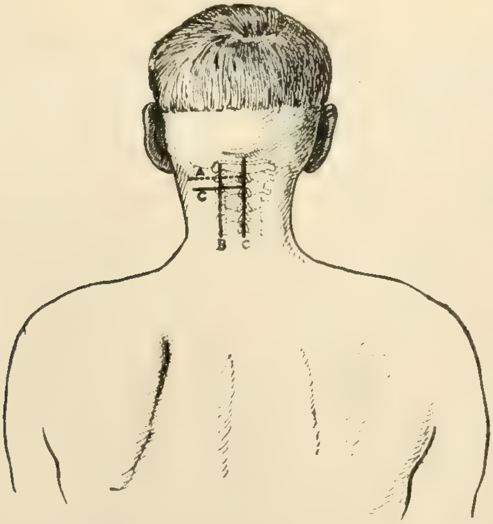

Fig. 577.—Various Incisions Employed in Operations for the Relief of Spasmodic Torticollis. *A*, Horizontal incision of Keen; *B*, vertical incision of Noble Smith; *C C*, T-shaped incision suggested by Author.

capitis posticus major, and the inferior oblique of the opposite side; it will manifestly be antagonized by the partners of the muscles mentioned, *i.e.*, the posterior rotators of the same side.

Elevation of the chin—extension at the occipito-atloid joint—will be increased by those muscles on both sides which are attached behind the line of the foramen magnum—that is, by practically all the muscles except the two anterior recti, the lateral recti, and the inferior oblique.

The *forward projection of the head* (with the resulting apparent shortening of the neck) is largely due to the action of the sterno-mastoids.

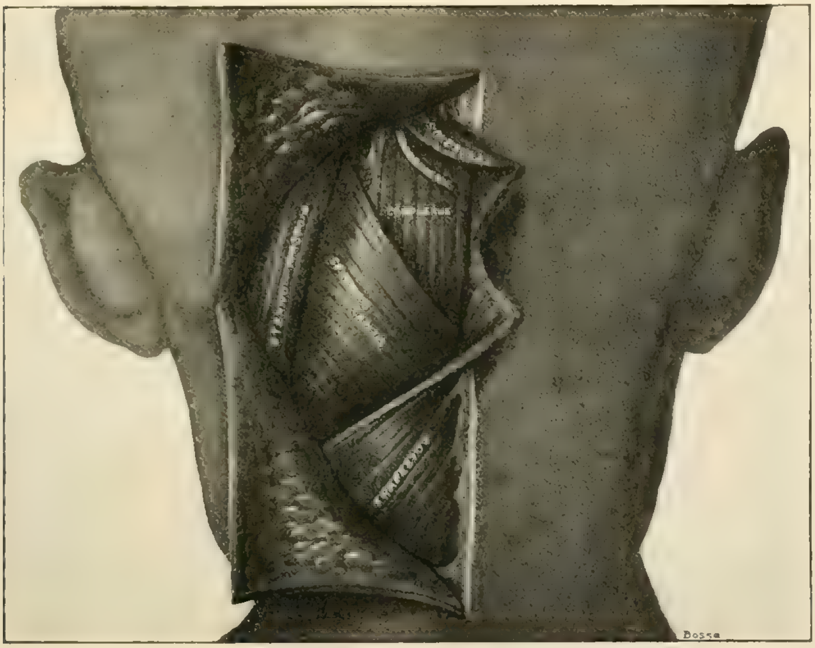

FIG. 578.—From a Dissection by the Author. The trapezius has been divided in such a manner as to expose the great occipital nerve as it emerges from the complexus muscle.

Various muscles participate in the spasmodic action, the most frequent combinations being that of the sterno-mastoid of one side with the trapezius of the same side and the posterior rotators—viz., the splenius, rectus capitis posticus major, and the inferior oblique—of the opposite side.

The nerve supply of the more important of these muscles is as follows: The sterno-mastoid and the trapezius are chiefly supplied by the spinal accessory; in addition, branches from the anterior divisions of the second, third, and fourth cervical nerves enter these muscles, part of their fibres joining the spinal accessory, part going directly to the muscular structure. (The origin of the spinal accessory is well known; its course will be briefly considered under Operative Treatment.)

The posterior muscles, on the other hand, are supplied by the posterior primary divisions of the cervical nerves. (Figs. 578, 579, and 580.) The first of these emerges between the occiput and atlas and is found beneath the complexus muscle in the suboccipital triangle, where it lies below the vertebral artery—that is, between the artery and the inferior oblique muscle. It supplies muscular branches to the complexus, the rectus capitis posticus major and minor, and the superior and inferior oblique. Ordinarily the posterior primary divisions of the cervical nerves divide into internal, cutaneous, and external muscular branches; the suboccipital is an exception to the rule, as it gives no internal or cutaneous branch. The posterior primary branch of the second cervical emerges between the atlas and the axis and is then directed still farther backward between the inferior oblique and the semispinalis colli. Beneath the complexus it gives off a branch to the inferior oblique and then divides into external and internal branches. The external twig is muscular, being distributed to the complexus, while the internal, much the larger of the two, is distributed, under the name of the great occipital nerve, to the posterior part of the scalp. This latter nerve, which is purely cutaneous, serves as the guide to its own muscular branches and to the neighboring nerves, above and below, with which it communicates; it forms the so-called posterior cervical plexus. The third nerve (posterior primary division) is much smaller and gives branches chiefly to the com-

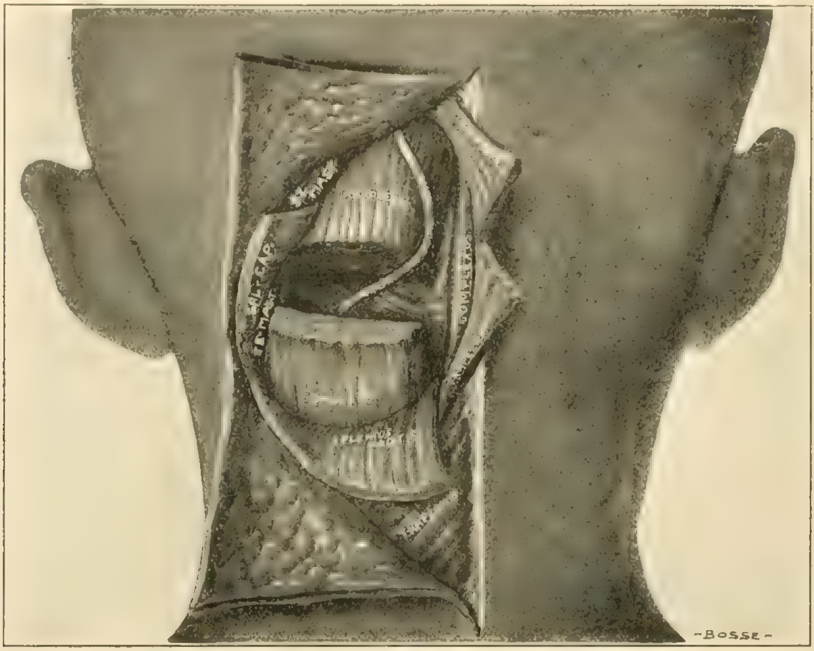

Fig. 579.— From a Dissection by the Author. The trapezius, splenius capitis, and complexus have been divided in such a manner as to expose the inferior oblique muscle and the great occipital nerve.

plexus, splenius capitis, and trachelo-mastoid muscles. The posterior primary divisions of the lower cervical nerves supply contiguous muscles, and will therefore give a small part of the supply to the longer of the posterior muscles described. The lateral and anterior recti are supplied by branches from the anterior primary divisions of the upper cervical nerves. To sum up, the chief supply of the sterno-mastoid and trapezius is the spinal accessory, while the posterior muscles derive their nerve supply from the posterior primary divisions of the upper three cervical nerves. Excision of these seems to be sufficient to overcome the spasm; and while the nerve supply that remains does not interfere with the results of the operation, its presence may help to explain why more extensive paralyses do not follow and why, as has been elsewhere referred to, the posture and movements of the head are not interfered with. (According to some authors, a part of the supply of the upper part of the trapezius is also derived from the posterior primary divisions of the cervical nerves.)

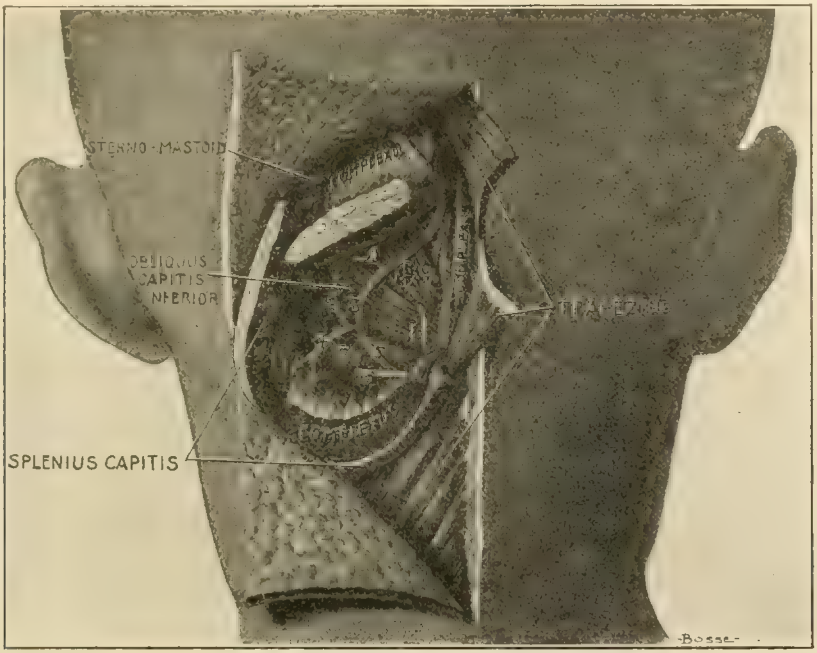

FIG. 580.—From a Dissection by the Author, Showing the Posterior Primary Divisions of the Three Upper Cervical Nerves.

Etiology.—Numerous causes have been adduced, but none determined; indeed, many of the causes assigned are so vague and have manifestly so little bearing on the disease as to be of small value. Gowers states that the affection is more common among women than among men. In this country, according to Osler, the reverse is true. According to Whitman the affection is about evenly divided among the sexes. It is a disease of adult life, as shown by the report of thirty-two cases published by Richardson and Walton (*Am. Journ. Med. Sc.*, Vol. CIX., page 27, 1895). These cases were distributed among the various decades thus: From 10 to 20 years, two cases; from 20 to 30 years, six cases; from 30 to 40 years, fifteen cases; from 40 to 50 years, three cases; and 50 to 60 years, three cases. The disease is said to attack those of neurotic taint, or the subjects of migraine, neurasthenia, and psychoses. It also follows exposure to cold, otitis media, malaria, attacks of rheumatism in the muscles of the neck, and injuries to these muscles or to the head. In many cases defects of vision—myopia, hypermetropia, or insufficiency of the ocular muscles (see special forms)—have been assigned to a place in the etiology. Starr, however, does not deem these sufficient to originate the disease, and Richardson and Walton found that the relief of these defects did not cure the deformity. According to certain writers, cerebral palsies stand in a causal relation to a small number of cases in which neck deformities are associated with movements of eye or arm. It must be very rare indeed that the brain lesion, in a cerebral palsy, is limited to such an area of the cortex as to give a typical case of spasmodic torticollis. In a certain number of cases the affection appears to be due to overaction of the muscles and therefore related to craft-spasm. Chiene ("Allbut's System," Vol. 8, page 27) relates a case of his own that occurred in a tailor who, "when he drew a stitch turned his head to the right by action of the left sterno-cleido-mastoid. This muscle became involved in spasm and at the same time some of the small muscles of the hand were implicated to such an extent that the disease would have been called one of craft-palsy had there been no torticollis." He also relates a case of Annandale's which resembled craft-palsy. In one of the writer's cases, that of an umbrella maker, the patient's work necessitated turning his head constantly to the left, and the muscles on the right were involved in spasm (Fig. 572).

Pathology.—The pathology of this disease is not understood. It is agreed that it is not primarily a muscular, but a nervous disease, although no lesion has been demonstrated in the tissue. When it is remembered how inextricably the nerve tissue is associated with the other tissues, the difficulty of deciding whether an initial lesion is located in the neurons or the allied cells will be readily conceded. If it be assumed, however, that the disease is primarily nervous, the questions which present themselves are: (1) What is the nature of the lesion? (2) Where in the nervous circuit—sensory nerves, motor nerves, spinal reflex centres, or cortical centres—is it located? To these questions satisfactory answers cannot now be given.

In some cases the disease appears to be reflex, due to irritation of the sensory nerves of the neck, and is preceded by neuralgia; in others the irritant is fatigue, a result of voluntary overaction, and dependent upon a constrained attitude assumed because of the patient's occupation or following some defect in vision. Starr believes that the location of the lesion is almost entirely cortical, the irritant acting on those cortical centres which control the movements of the head. He locates the resulting functional disturbance in the entire nervous mechanism concerned in moving the head; "motor and sensory elements being equally affected and thrown into a state of hypersensitiveness, whereby slight sensations produce undue movements."

Chiene suggests that the affection may begin in the deep origin of the spinal accessory and overflow through lines of lessened resistance to the adjacent nerve centres, and in favor of this belief he cites the following facts:—that when, in faradization of the cortex, electrodes are placed near together, limited spasm is produced; and that when this is repeated several times, or when the current is increased in strength, the spasm extends to other muscles and may ultimately affect all of one or of both sides. The fact that, when effort is made—for example, in some action that requires force and at the same time delicate adjustment—the discharge of the cerebral cortex normally spreads to contiguous centres, must not be forgotten in this connection. This hypothesis of a cortical origin receives some support from the following facts cited by Starr: (1) Movements, in these spasms, are similar to those produced by volition. For example, the eyes are turned toward the side to which the face is rotated, and the eyebrows are elevated; or, when the arm is involved, the motions are such as would be produced in a normal individual striving to move the head in a position of extreme rotation. Unfortunately, these arguments are weakened by the difficulty of precisely separating the voluntary and involuntary factors. (2) In many cases muscles on opposite sides of the body, that are supplied by various nerves, combine to produce the movement. Particularly is this the case when the sterno-mastoid and trapezius of one side are assisted by the posterior rotators of the opposite side. In our present knowledge such combinations could be effected only through the cortex.

With reference to the mental or neurotic origin of the disease, Kollarets (*Perosi Hetila*, Nos. 21, 22, 1905) believes that every case of spasmodic torticollis is of mental origin and a side phenomenon of hysteria, which may exhibit no other symptom, and in proof of this he cites three cases in all of which there was a faulty heredity. In the first, a tumor of the head; in the second, a paræsthesia of the neck; and in the third, a trauma of the same region called the attention of the already hypochondriacal patient to the region of the neck. Meige and Feindel (*Archives générales de Méd.*, 1902) conclude that any number of spastic states modified by tics, cramps, chorea, myotonia, etc., may develop on the same neuropathic soil which has given rise to mental wry-neck, and that the latter is only a motor emanation from this psychopathic basis.

Because of its bearing on the resemblance between certain cases of spasmodic torticollis—due to overaction of certain muscles—and cases of craft-palsy, it seems permissible to mention Destarac's opinion * that torticollis depends on a disturbance of muscular tone, a lack of muscular balance. The relaxation of spasm which follows, in some of these cases, the support given to the head by even one finger of the patient is explained by this authority in accordance with Sherrington's law, viz., that stimulation of a voluntary muscle produces relaxation in the antagonist muscle. Other points of resemblance lie in the fact that certain cases of spasmodic wry-neck are caused or increased by mental excitement or grief, and that the spasm is often provoked by the consciousness of being observed. For cases such as these no sufficient pathological basis has been established. In this connection, however, it is interesting to recall to mind the reflections of Poore,* who, describing craft-palsies, points out how consciousness, may interfere with and spoil certain complex automatic acts.

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* Annales de Méd. et de Chir., 1902.

These theories and opinions, while they prove nothing conclusive as to the pathology of the disease, suggest very strongly, in the majority of instances at least, that not only are the kinaesthetic areas of the cortex involved, but that higher or controlling centres are also implicated; and that, when the spasms are terminated by the support of a finger, it is through the operation of Sherrington's law, or because control is better exercised through unusual lines of association, or because consciousness, for the time being, has been removed from the erring centres.

Keetley, on the other hand, believes that traumatism, middle-ear disease (by producing a chronic meningitis), and exposure to cold and wet and to malarious influences are more than likely to be the true causes of the affection.

Symptoms.—The most important and distinctive symptom, particularly in the early typical cases, is a more or less sudden *spasm* in either the sternomastoid or the trapezius, or in both—a spasm which jerks the head to one side, while at the same time it turns the face to the opposite side. Following the spasm there is an interval of relaxation, during which the head is voluntarily returned to the normal position. The spasms vary as to their frequency, duration, and severity, and also as to the particular muscles, or groups of muscles, which are involved; and while these variations may be observed, not only in different cases, but at different stages of a given case, the distinctive features remain the same.

This alternate spasm and relaxation may occur as often as eight or ten times to the minute, or the spasm may occur more slowly and last longer. (Starr.) During the earlier stages, when the symptoms are likely to be less severe, the contraction may be feeble and partially controllable by voluntary effort or by slight artificial support, and the intervals between the spasms are long. Later, the spasms increase in frequency and duration and become uncontrollable. Finally, in the more severe cases, the clonic contractions become tonic, the head is held permanently in the faulty position, and, while occasional relaxations may occur, a complete return to normal is not possible, because the muscles have become more or less shortened.

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* Allbut's System, 1901; vol. viii., p. 6.

The spasm may be increased by nervous excitement, by voluntary effort, even talking, particularly by efforts directed to the control of head movements, and, in the later stages, by any force employed for their control; it relaxes during sleep, except in very prolonged and severe cases, and often as a result of pressure, even very slight, applied to some point of the head or face. In a case of the author's the slightest pressure of the tip of the patient's index finger applied to the point of the chin served to bring a severe spasm under control.

Pain is not a necessary symptom of this disease. Occasionally there is a soreness or stiffness of the overacting muscles. Sometimes the condition is acutely painful, the pain being cramp-like in character, and perhaps referred to the great occipital nerve or running down the arm. Soreness and stiffness of the neck muscles, accompanied by slight twitching of these muscles, may be the very earliest symptoms of the disease.

As the muscles involved in spasm and the resulting deformities vary, a knowledge of the various muscles and groups of muscles will help very much to understand the complex cases. The different actions of the muscles having already been considered, it is necessary to repeat here only the most prominent of these. Usually the spasm begins in either the sterno-mastoid or the trapezius, or both these muscles are affected simultaneously. When the former muscle is involved, the head is drawn downward toward the shoulder of the affected side and somewhat forward, the chin is elevated, and the face is turned to the opposite side. Involvement of the trapezius produces a similar deformity, the rotation and tension becoming more marked, while the forward displacement is less pronounced. When both muscles are involved, all elements of the deformity are increased, except the forward displacement. From the muscles just mentioned the spasm may extend to the muscles of the opposite side of the neck, particularly to the deep rotators—the splenius capitis, the inferior oblique, and the rectus capitis posticus major. When this occurs, all the phases of the deformity are increased, with the possible exception of the lateral bending. Rarely, corresponding muscles on opposite sides are involved, and when this takes place the characteristic rotation is, of course, absent. Thus, when both sterno-mastoids are involved, the chin is depressed; when both the trapezii, the head is markedly drawn backward (retrocollic spasm).

Involvement of the deep rotators on the side of the affected sterno-mastoid and trapezius would serve to counteract the effect of the latter. In a long-continued case the muscles of the face, chest, arm, and back may become involved.

There is no change in the electrical reaction of the muscles. They become hypertrophied, however, from constant overaction and ultimately diminish in length, producing more or less deformity. Antagonist muscles, through their constant voluntary efforts to control the movements, also become hypertrophied, and, as a result, the circumference of the neck is frequently greatly increased. Spinal curvature, with the convexity toward the sound side, often develops as a result of the contraction and shortening, and a second compensatory curve may and sometimes does occur, lower down.

The *course* of the disease varies. Its onset is usually gradual, the spasms increasing in frequency, intensity, and duration. Occasionally the attacks diminish gradually and eventually cease. Recurrences are liable to take place, even in the mild cases; they are almost certain in the severe ones, and may continue for the remainder of the patient's life. Spontaneous recovery is rare. The disease is not attended by convulsions or cortical epilepsy. (Starr.) A frequent complication is hysterical agitation, due in some degree perhaps to the fact that the patients are neurotic.

Diagnosis.—The ordinary case is recognized with little difficulty. Gowers states that cases occurring in women under thirty are particularly liable to be of hysterical origin. In such cases the spasm usually extends from the neck to the trunk, and the diagnosis is confirmed by other symptoms of hysteria. Chiene points out that most of the cures effected without a resort to neurectomy have been performed in females under thirty, which fact suggests strongly, according to this author, their probable hysterical origin. To decide on the particular muscle involved in a given case is not always easy. In this, great aid will be afforded by adding, to an analysis of the deformity, inspection and palpation of the muscles.

Treatment.—The treatment of spasmodic torticollis is unsatisfactory, because so little is known of the pathology and etiology of the disease. It may be divided into medicinal, mechanical, and operative.

MEDICINAL TREATMENT.—Most writers agree that treatment by drugs is nearly useless. Osler says that temporary relief is sometimes obtained, but that a permanent cure is exceptional. Nevertheless, in the early and less severe cases it may be worth while trying some of the various nerve tonics, hypnotics, or narcotics. Of these a suggestively long list has been recommended, among which may be mentioned: arsenic, phenacetin, quinine, the bromides, chloral, assafœtida, valerianate of zinc, cannabis indica, tincture of belladonna, atropine, and morphine. Tincture of belladonna in physiological doses is praised by Starr, and, according to the same author, atropine injected into the affected muscles has, in some cases, given relief. Morphine should be given with great caution because circumstances are here most favorable toward acquiring the morphine habit. Counter-irritation by cautery or blister is lauded by some and dismissed as useless by others—a diversity of opinion which is held concerning most of the remedies mentioned.

In a case of Dr. Poore's, quoted by Chiene, the patient suffered from a marked form of torticollis, had suffered earlier from syphilis, and was cured of the torticollis by mercury. This indicates that, in all cases, means should be directed to the cure of any specific or constitutional affection. Appropriate hygienic measures, too, should always be adopted.

Mechanical Treatment.—Mechanical treatment embraces electricity, massage, and any form of support. The use of *electricity* is empirical, as there is probably no disease of either muscle or nerve on the affected side. Electricity applied to the muscles of the opposite side, in the hope of strengthening them, is also useless, as the disease is not due to weakness of the opposing muscles; and, further, not even the strongest voluntary contraction is sufficient to overcome the spasm. (Starr.) If used, as it may be, in the less severe cases, or as a preliminary treatment, it should be applied in the form of galvanism to the affected, in that of faradism to the sound, side.

Massage is recommended only in the early mild cases. *Mechanical supports* are highly commended by some writers, and they may be devised to suit the particular case. (See Figs. 561 to 564; also Figs. 569, 570, 573, 574, 575.) Thus, Cheyne made use of a photographer's head-rest attached by an iron rod to a poroplastic band around the chest. The head was not fixed to the rest, but the latter was so arranged that the patient could bring his head against the rest whenever he chose. A simple form consists of a band around the head and another around the chest, the two being connected by means of rigid or elastic bands at whatever points desired. An even simpler support may be constructed from rubber bands attached to the skin by adhesive plaster. The value of support is based on the observation that many patients can, by the merest pressure of the finger against the chin, control the spasms. Chiene believes that mechanical supports are but makeshifts, and calls attention to the fact that none is ever as effective as the patient's finger. There can be no doubt, however, that in exceptional cases, particularly in the less severe, supports are capable of giving a great deal of comfort.

To sum up, it may be stated that only in the early and less severe forms can much be hoped for from medicinal and mechanical treatment. Even here the benefits are often only temporary. Nevertheless, in these cases, as in all others, any source of mental anxiety should be removed and predisposing occupations avoided, and, if there is a neurotic element, treatment should be directed against this. Massage, combined with carefully regulated exercises and sometimes mechanical support, may, in the milder cases referred to, be of some service; in the severe forms they are likely to be wholly unavailing. Richardson and Walton state that it is their practice in nearly all cases to recommend massage and hygienic measures only until the patient is reconciled to operation.

Operative Treatment.—Reports of successful cases, in recent years, have established the value of operative measures beyond a doubt. In all severe, well-marked cases, it offers the only hope—in many it effects a cure. The various operations recommended at different times by one or another operator are as follows:

(*a*) *Tenotomy.* This operation may be dismissed with the brief statement that, once repair has taken place, the spasms return.

(*b*) *Neurotomy.* The same criticism may be applied to this. Once the nerve regenerates, the spasms occur. As a matter of course such recurrence may be, and is usually, longer delayed than when the muscle is cut, and for obvious reasons.

(*c*) *Neurectomy.* Of all methods this alone offers the most reasonable hope, and only in very recent times has its worth been established.

(*d*) *Muscle section* (Kocher's operation).

Most authors agree that the first operation to be undertaken is neurectomy of the eleventh nerve—the spinal accessory. This nerve, as is well known, does not supply all of the sterno-mastoid and trapezius; branches from the second, third, and fourth cervical going to both of these muscles; and, in addition, muscular branches from the posterior primary divisions of the cervical nerves are supplied to the trapezius. The bulk of the supply to the sterno-mastoid, and to the upper fibres of the trapezius, is furnished, however, by the spinal accessory. As a matter of observation, it has been established that neurectomy of the eleventh appears to be effective not only when the sterno-mastoid and trapezius are involved, but also where the spasm has already extended to other muscles—for example, the posterior rotators. If, after neurectomy of the eleventh, the spasms remain, or if, after a period of improvement, they return, the nerve supply of the posterior rotators—that is, the posterior primary divisions of the three or four upper cervical nerves—should be cut; and, in the event of contraction of the muscles having taken place, the muscles themselves should also be cut across. When, however, there is evidence of extensive and well-marked involvement of the posterior muscles, prompt interference with their nerve supply is justifiable, and when the spasm is confined to these muscles—retrocollic spasm—it may be the only operation required.

Operations on the Trunk of the Spinal Accessory Nerve at the Point where it Emerges from the Jugular Foramen, along with the Pneumogastric. (Fig. 576.)—The spinal portion of the spinal accessory nerve, the only part that concerns us here, lies in the upper part of the neck, between the internal carotid artery and the internal jugular vein. After it leaves these it runs obliquely downward and outward, usually in front, or occasionally behind, the vein. Descending beneath the sterno-mastoid for nearly an inch, it enters the deep aspect of this muscle about one inch and a half (sometimes as much as two inches, according to Gray) below the tip of the mastoid process. Piercing the muscle it supplies it and, emerging from the middle of its posterior border, continues across the posterior triangle of the neck and is finally distributed to the deep aspect of the trapezius. In the sterno-mastoid the nerve is joined by branches from the second, in the posterior triangle by branches from the third and fourth cervical nerves.

Guides.—The linear guide is a line from midway between the angle of the jaw and the tip of the mastoid process to the middle of the posterior border of the sterno-mastoid, thence, continuing in the same direction, across the posterior triangle. The deeper guides are the posterior belly of the digastric, the internal jugular vein, and the transverse process of the atlas, which is felt midway between the tip of the mastoid and the angle of the jaw.

An incision, from two to three inches in length, and with its centre about opposite the angle of the jaw, should be made along the anterior edge of the sterno-cleido-mastoid muscle, as the nerve usually enters the muscle at about this level. The edge of the muscle is first exposed and then its deep aspect, the whole muscle being turned outward so as to expose the deeper guides. The transverse process of the atlas is easily exposed and recognized. In front of this, running downward and forward, is the posterior belly of the digastric. Behind the digastric, and more deeply placed, are the great vessels. At this level the spinal accessory emerges from beneath the digastric. According to E. Eliot, Jr. (*Annals of Surgery*, May, 1895), the nerve has the following relations to the transverse process of the atlas: "Never above it, sometimes directly over it, usually a fraction of an inch in front of its most prominent part." From this point to its entrance into the belly of the muscle the nerve may be isolated with safety and without difficulty. A segment, from three-quarters of an inch to an inch in length, should be excised. If the nerve is not readily found, Richardson suggests drawing the finger nail firmly across the bottom of the wound, as such pressure upon the nerve causes the muscles to contract. This nerve is frequently exposed during dissections for the removal of the deep lymph nodes, and it may always be identified by slightly irritating the nerve by forceps or the handle of a scalpel, care being taken to observe accurately the first contraction, as a second may not occur for some time. If the sterno-mastoid has become shortened, it may be divided, as in congenital torticollis.

The wound is closed in the usual manner. After the operation, spasm ceases in the sterno-mastoid, although it may remain in other muscles. Often, after the lapse of a few days, spasm in these muscles also ceases. Fixation of the head is not necessary, according to Whitman, who also advises that the operation be supplemented by massage and muscle training. Chiene calls attention to the paralysis which may ensue, but states that, although spasms cease, the power of the muscles is soon regained through their cervical nerve supply. This, he adds, may be hastened by the employment of galvanism and massage.

Following this operation, spasm may continue in the posterior muscles of the same or the opposite side, usually the latter, or spasm may spread to these muscles for the first time. It then becomes necessary to excise the posterior primary divisions of the three or four upper cervical nerves. The dissection has to be made at a considerable depth, and the operation is, for this reason, rather difficult. A good light and careful recognition of the structures at each step are matters of importance. There are two operations—Noble Smith's and Keen's. (Figs. 577, 578, 579, and 580.)

Smith operates through a vertical incision which is three inches long (Fig. 577) and which runs downward from the level of the external occipital protuberance, parallel to and one inch from the spinous processes. In his first reported case,* he excised a piece of the external division of the second, third, and fourth cervical nerves. Raising the splenius he cut the nerves as they entered the muscle; he did not molest the suboccipital nerve, although he wished to do so. The result was good. This method does not expose either muscles or nerves sufficiently, and it is more than probable that the suboccipital nerve would rarely be found during the course of this operation.

Keen's operation is described by the author in substantially the following terms (*Annals of Surgery*, Vol. XIII., 1891, p. 45). There are seven distinct steps.

(1) Make a transverse incision one-half inch below the level of the lobule of the ear, two and one-half to three inches long, beginning at the median line or slightly beyond. (Fig. 577.)

(2) Divide the trapezius transversely in the line of the skin incision.

(3) Dissect up the trapezius, identify the great occipital as it emerges from the complexus about half an inch in from the median line, and usually about half an inch below the incision.

(4) Divide the complexus transversely at the level of the nerve by repeated shallow cuts. Expose the trunk of the posterior division where it emerges between the atlas and the axis, and exsect a portion (half an inch or more) of it before it divides. (This destroys the great occipital; but, according to Keen, this destruction is of no importance.)

(5) Recognize the inferior oblique by following the great occipital toward its point of emergence, where it passes below the lower border of the muscle.

(6) Recognize the suboccipital triangle—the inferior oblique is its lower boundary; the nerve lies in this triangle, close to the occiput, but below the vertebral artery. Exsect as close to the spine as possible, taking care to avoid the artery.

(7) One inch lower than the second will be found the third cervical nerve, the external branch of which should be excised close to the point of bifurcation.

REMARKS.—The muscles divided may be united if desired; in case they are shortened it is better to leave them without suturing. Drainage may be provided, but the wound is so well placed that it is scarcely necessary.

It will be noted that Smith excised the external branch of the second, third, and fourth cervical nerves, but left the suboccipital; Keen, on the other hand, excised the first, second, and third; and the results appeared to be equally good. It is, of course, impossible to excise all of the nerves entering the longer of the posterior

* Reported in the Boston Medical Journal, vol. i., 1891, p. 752.

head muscles, as that would involve all of the posterior primary divisions of the cervical and of the upper dorsal nerves. Besides, the same rule holds good in the posterior as in the anterior muscles, namely, that it usually suffices to destroy the main and is not necessary to abolish the whole nerve supply. It would seem more important, however, to excise the suboccipital than the fourth, for the reason that the former is the main supply of the inferior oblique and rectus capitus posticus major, while the fourth supplies only a fractional part of the longer muscles—complexus, splenius, etc. Smith's suggestion as to lifting the splenius and cutting all the nerves entering into its under surface is valuable. The step should not be adopted until the operation in other respects has been made as complete as possible; it might then be applied to all of the muscles which it has been necessary to raise during the operation. This procedure alone, however, could not be depended upon for a cure, as there is great likelihood that regeneration of the divided nerves will sooner or later occur. The vessels which one may expect to encounter are the vertebral artery in the suboccipital triangle, and branches of the occipital artery. The former must be carefully avoided. A plexus of veins in the areolar tissue around the vertebra may give trouble, not so much on account of their size as because of the difficulty of securing them.

The writer believes that Keen's operation is superior to Smith's, but would suggest the following modifications: (*a*) The incision should be T-shaped, one limb extending vertically along the median line, from the occiput to the fifth or sixth cervical vertebra, while the other, two and one-half to three inches in length, is placed horizontally about one inch below the level of the lobule of the ear and meets the median incision. (Fig. 577.) This gives a wider exposure and is so placed that when the trapezius, after it has been raised by blunt dissection, is cut in the line of the horizontal limb of the incision, there is no danger of wounding the great occipital nerve. The horizontal incision is more nearly on the level of the point of emergence of this nerve from the intervertebral foramina than it is on that of its exit from the complexus.

(*b*) There is no need of dividing that portion of the complexus which lies between the exit of the nerve and the spinous processes. In cutting the external portion of the complexus it seems better to cut first the splenius transversely.

(*c*) The least occipital, the external or cutaneous branch of the posterior primary division of the third cervical, is often exposed in the median incision. No attention need be paid to the nerve, but in case it appears, it will, when pulled on, serve as a guide to the third. The latter lies in the same vertical plane as the second, the thickness of one vertebra—that is, about three-quarters of an inch—lower down.

Muscle Operations.—Kocher advises excision, complete or partial, of the sterno-mastoid, combined with section of the posterior muscles where these are involved. He operates on the latter through a transverse incision similar to that of Keen. When the posterior muscles of both sides are involved, an incision is made from one mastoid process to the other. This operation is more sanguinary, but of simpler technique, than those performed on the nerves.

Results.—Kalmus (*Beitr. zur klin. Chir.*, Vol. XXVI., 1900) gives the following statistics:—In 68 cases of resection of the spinal accessory, 23 were cured, 20 more or less improved. In 15 of the above cases there was performed subsequently excision of the posterior cervical branches, 10 cures resulting. Mentz (*Deutsche Zeitschrift f. Chir.*, Vol. LXII.) reports 12 cases operated on by Kocher's method, with 7 cures.

The majority of reports strongly favor neurectomy as opposed to muscle operations. Attention, however, must be called to the fact that the extensive muscular sections necessary in the nerve operations may be an important factor in the success of the latter. If this be true it adds to the resources of the operator, who can, when he has failed to locate the nerve, at least divide the muscle and, lifting it up, cut all the nerves entering and emerging as recommended by Smith.

It is assured by all authors that no permanent paralysis results from these extensive operations, whether upon nerves or upon muscles. Chiene's suggestion that, in the most obstinate cases, that portion of the cortex which presides over the affected muscles should be excised, has probably lost much of its importance since the introduction of Keen's operation. In any event it should not be attempted until the peripheral motor supply to the various muscles has, as far as possible, been excised.

Prognosis.—Life is not shortened even in severe cases, as the disease does not spread to vital parts. Spontaneous recovery may and does take place, and is most likely to occur in young patients who suffer from mild attacks at infrequent intervals. The mild forms may be benefited by treatment; both the mild and the severe forms may be cured, or at least benefited, by operation. The outcome should be predicted with great care, it being remembered that the gravity is increased by sudden onset, severe spasms, by wide involvement of muscles, and by the length of time which has elapsed since the disease first manifested itself. Following neurectomy, spasm may develop in other muscles, since it is not the diseased cerebral nervous organ, but only the peripheral nerves which have been operated upon. (Kalmus.) It is held by some writers that the cases reported as spontaneous cures, or indeed any cures that have been effected with operative interference, have been, in part at least, hysterical.

IRREGULAR FORMS OF TORTICOLLIS.

Paralytic Torticollis.—This variety may be due: (1) To paralysis of the spinal accessory nerves, which may occur as a result of anterior poliomyelitis, as part of a progressive muscular atrophy, in bulbar paralysis, or as the sequence of compression by meningeal exudates, bone caries, trauma, or rheumatism. (2) It may be the result of an arrested development of muscles dependent upon some lesion of the nerves or of the nerve centres (*e.g.*, cerebral apoplexies). (3) It may follow diphtheria.

The deformity of the neck in nearly all of these cases is symptomatic and approaches the typical only when there is paralysis limited to one or several muscles on the same side, a condition most likely to follow trauma, rheumatism, local exudates, or a limited degeneration of motor nuclei. In progressive muscular atrophy the paralysis is apt to be bilateral, involving the trapezii and permitting the head to fall forward, or the sterno-mastoid, the head falling backward. After diphtheria the trapezii are liable to be implicated.

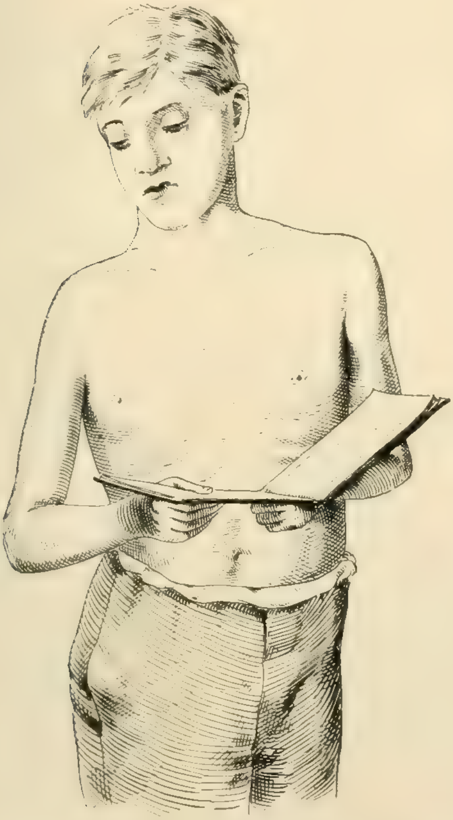

FIG. 581.—Shows the Attitude of the Head in Ocular Torticollis. (Bradford and Lovett.)

The diagnosis is based on a recognition of the underlying disease. When the muscles of only one side are involved there is a limitation of rotation toward the other side. The particular muscles implicated may be discovered by inspection, paralysis of the sterno-mastoid and trapezius appearing particularly on attempts to shrug the shoulders.

The treatment is directed against the underlying condition. When it is due to a central lesion little can be done. In all cases the nutrition and tone of the muscles should be preserved and improved by electricity and massage.

Golding Bird (*Guy's Hospital Reports*, 1890) believed that when facial asymmetry complicated torticollis the two were integral parts of the same affection, viz., a central lesion closely akin to anterior poliomyelitis. The facts that asymmetry occurs with the acquired as well as with the congenital forms of torticollis, that it improves and may even disappear after operation, and, finally, that it may even exist without torticollis, render this opinion untenable in all cases.

Psychical Torticollis.—Under this name Brissaud (*Union médicale*, 1894, page 161) described what he regarded as a peculiar form of rotary tic of the head and neck. This author noted that these cases were allied to epilepsy, neurasthenia, etc., and that the movements were easily controlled by the pressure made by a finger upon the head; and he concluded that they were due to a local paralysis of the will. Other writers have used the term in the same sense or have substituted therefor the term *mental*, while still others employ the latter in the sense that it shall include practically all cases of spasmodic torticollis. When it is considered that the great majority of spasmodic cases are probably central in origin, that they are often caused by strong emotion, fright or grief, that in most, perhaps all, there is a strong neurotic taint inherited or acquired, and that they are uncontrollable by any exercise of the will, it does not seem permissible to use the terms *mental* and *psychical* except in the broadest sense.

Ocular Torticollis.—This variety, according to Bradford and Lovett, may occur when there is a difference in the planes of vision of the eyes, or a difference in the power of the two eyes. Gould (*American Medicine*, 1904, Vol. VII., page 513) called attention to the fact that not only torticollis, but even a secondary compensatory spinal curvature, might result from certain ocular defects. His conclusions are as follows: (1) Habitual abnormal position of the head is frequently the cause of spinal curvature. (2) These abnormal positions may be due to some error of refraction which necessitates the torticollis, wry-neck, cant, or depression in order to secure clearer vision. (3) The error of refraction is usually a slight asymmetry of the axes of astigmatism, whereby the clearer-seeing or most-used eye (usually the right in right-handed persons) has an axis 10° or 15° to either side of 90° or 180°. (4) The heterophoria which has been the supposed cause of the functional torticollis, etc., is itself usually a result of the refractive error, proper correction of which at a sufficiently early age cures the heterophoria, the torticollis, and the spinal curvature. (Fig. 581.)

Physiological Torticollis.—A variety called physiological or habit torticollis has been described and is attributed to the habit of holding the head awry, the abnormal position being continued until the deformity has become permanent. It is probable, however, that many of these cases are, strictly speaking, ocular and that a true case of habit torticollis is very rare.

Torticollis occurring during rachitis or in connection with deformities due to basilar or cerebro-spinal meningitis are purely symptomatic. Whitman points out that a slight degree of deformity of the neck is sometimes seen in ill-nourished infants, and that this and cervical opisthotonos may be mistaken for symptoms of Pott's disease.

INFANTILE PARALYSIS.

(ANTERIOR POLIOMYELITIS.)

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Introduction.—In infancy and early childhood an inflammatory affection of the anterior horns of the spinal cord causes a more or less complete paralysis of some of the muscles of the body. One or more of the extremities are usually attacked, but occasionally the paralysis is quite generally distributed. The majority of the cases occur during the first ten years of life; at later ages the disease is encountered with varying degrees of frequency. In adult life, though a rare condition as compared with the infantile type and rather more difficult of diagnosis, still it is by no means unusual. Much importance attaches to its recognition because of the value, to the patient's ultimate functioning capacity, of an early appreciation of the nature of his loss in power.

Most of the instances of this paralysis are sporadic, but it does occur in epidemic form; and during the past ten years reports of a large number of apparent epidemics have found their way into the literature, some of them representing a considerable number of cases, but the majority including only very small groups.

Study of this condition has devolved upon two special branches of medicine, viz., the pediatric and the orthopedic. The acute phase of the disease is hard to recognize and is mistaken for many different conditions. The popular name so often given it—"teething paralysis"—indicates one of the most common conditions with which it may be confounded; and, as a matter of fact, its onset is often coincident with the eruption of a tooth during the first dentition. The arrival of a tooth is accompanied sometimes by quite a stormy set of symptoms, and the milder types of infantile paralysis are, in many cases, of no greater significance. As a rule, the general practitioner or the pediatric specialist is the one who sees the child during the acute onset of the trouble, when the symptoms are sufficiently severe to merit the calling in of professional assistance. Later on, when the loss of power is detected, a neurologist is commonly brought into the case; and at a still later date, when contractures seem either to demand division or treatment by means of apparatus, the orthopedist's aid is invoked. So it can be seen that, among the diseases which are of as frequent occurrence as anterior poliomyelitis, there is scarcely one that touches so many special lines of practice. This, as the writer believes, is rather unfortunate, for division of responsibility does not generally tend to the best results. The diagnosis in any stage, in the great majority of cases, should be made by the family physician, and he should be so equipped that he may carry out treatment until such time as the purely technical questions concerning apparatus and its adjustment arise. Then, if tendon transplantation, tendon lengthening, or merely tenotomy is required, the orthopedist can be brought in for the solution of such problems; but any case of infantile paralysis will do better under the intelligent supervision of one observer who is able to keep in constant touch with the patient.

Etiology.—The causative factors which enter into the production of anterior poliomyelitis are very difficult to determine. The sudden onset, the febrile course in the well-marked cases, and the general resemblance to other infections, seem to place it among bacterial diseases. Up to the present time, however, no constant bacteriologic findings have characterized the few autopsies which are on record, and lumbar puncture, from which procedure it was hoped that good results might be obtained, has failed to show any specific organism in the aspirated spinal fluid. Different bacteria have been reported by nearly all observers who have practised this method of diagnosis in infantile paralysis. Very few patients die from this disease, and therefore there are very few pathological reports upon which to base conclusions. The epidemic character of the disease in some instances points rather strongly to an infectious origin, but there is no evidence that it is transmissible directly from one person to another. In an epidemic which occurred in Gloucester, Massachusetts, in 1900, and which the writer had the privilege of observing, there were two cases that developed in the same house, one showing signs of the disease twenty-four hours before his cousin, who lived on the floor above him, was attacked. Under the writer's observation have come two brothers, who developed paralysis within a very short time of each other. The infection, however, in these epidemics, seems to be a miasmatic one, to use an old and very indefinite term. In epidemics as large as that which occurred in Cherryfield, Maine, or as the Gloucester epidemic, or as the still more famous one in Vermont, where one and hundred thirty cases occurred, it is necessary to assume that some infective material was present in a comparatively restricted area, and that it found appropriate local conditions in the children whom it attacked; otherwise we must assume that all these patients were the hosts of an organism which had lain dormant until the climatic conditions necessary for its development supervened. It is difficult to believe that either assumption includes the whole truth. What few bacteriological observations on this disease are in our possession indicate that several different organisms may be responsible for the infection. In the epidemic forms, at any rate—it being assumed that healthy individuals are acting the part of hosts—it seems unlikely that there could be as great a variety of possible organisms as the number of cases would indicate. If the problem be viewed from this point it will appear more rational to assign a common bacteriologic factor to the epidemic type of anterior poliomyelitis. As for the sporadic cases, it is possible that one of several organisms may play the part of causative factor, although it seems more reasonable to suppose that a disease whose clinico-pathological manifestations, both in the epidemic and in the sporadic form, show such uniformity of character, must be caused by a specific bacterium whose identity has thus far escaped detection. It has been sought to identify the development of infantile lesions with the exanthemata and other infections of infancy and childhood, but no considerable number of cases of anterior poliomyelitis have been shown to be so related. In the case of Gloucester, the city had been afflicted with an epidemic of diphtheria only three or four years before that in which the epidemic of infantile paralysis occurred. While the investigation of the latter epidemic was in progress, the drainage system of the city was overhauled. On account of the rocky character of the soil at Gloucester it has been impossible to lay sewers, and therefore each house, except in a few scattered localities, has its own cesspool. These were cleaned out all over the city at the time of the diphtheria panic, so that imperfect drainage could scarcely have played any part in that particular epidemic of anterior poliomyelitis. In North Adams, however, where there was a small epidemic, it has been shown that all the cases occurred along the borders of a mill-stream that runs through the centre of the town. If "miasmatic" influences are to be taken into account in considering the etiology of this disease, it is difficult to understand their operation in the Gloucester epidemic. The town is situated near the end of Cape Ann and is nearly surrounded by the ocean, a tide river separating the mainland from what is practically an island joined to this mainland by a causeway. The island contains a good deal of high ground, there is very little swamp or marsh-land, and the Atlantic winds blow across it almost constantly. And yet in this epidemic the cases occurred on high land as well as low, along the tide-water river, and in houses almost overhanging the harbor waters. In this epidemic the sources of food supply were studied carefully. There was no conspicuous absence of cases on the milk route of any particular dealer, and provisions of all sorts were so variously purchased that no possible source of infection was discoverable in this connection.

It has been noted that the majority of the cases of infantile paralysis occur in the summer months. This has been true of the epidemics, and is true of the sporadic cases as well. In the Gloucester epidemic the cases grouped themselves in a rather striking way about the hot periods. When there were groups of two or three days of excessively hot weather there were noted on these days, almost invariably, more cases of infantile paralysis than on the cooler days either preceding or following these dates. These observations could not, as must necessarily be the case, partake of an absolutely accurate character, because the parents were not always able to fix the date of the onset of symptoms. So far as temperature has any influence upon the development of symptoms, it would seem to be a contributory factor. Humidity and sudden changes in temperature seem to have an effect in lowering local resistance and in stimulating organisms already within the body to produce their specific tissue changes. In several of the reports given by the parents of the Gloucester children, attention was called to the fact that there had been a sudden drop in temperature on the day upon which the children were seized with acute symptoms. Three cases were noted in children who attended a picnic one very hot day. During the afternoon a severe shower came up and the mercury fell thirty degrees in a little over an hour. Within the next thirty-six hours all three of the children showed well-developed signs of infantile paralysis. In one case a prolonged stay in the water on a hot summer day seems to have been the exciting cause for the focalization of the specific process. We see a very similar condition of affairs in osteomyelitis. Frequently the history of these cases brings out the fact that swimming for an inordinately long time has been immediately followed by the onset of an acute fulminating osteomyelitis. In these cases it is fair to assume that the staphylococcus was not taken into the patient's circulation at the time, but that in all probability the individual had been acting as the host of these organisms for an indefinite period, and that when local resistance had been sufficiently reduced—as by the exhausting influence of the prolonged swimming—they had set up acute suppurative changes in the bone marrow.

The influences which make one sex more susceptible than the other to a given disease do not operate in anterior poliomyelitis. Boys and girls are attacked with about equal frequency. Why the first decade should be the period of life when the majority of cases are noted is not apparent, unless it be that, during that period of rapid growth and active metabolic change, the mechanism which regulates the radiation of bodily heat is susceptible to more rapid and extreme fluctuation than in more mature years. In consequence of these rapid changes in the heat-regulating mechanism it is conceivable that local resistance in central portions of the body may be depressed below the point where it can withstand infection. This hypothesis would seem to receive some support from the clinical side and from analogy with osteomyelitis and some other infections. The cases which occur in adult life are, as a rule, not so typical in their onset and clincial course as those which develop in infancy. Furthermore, the study of the etiology of these cases presents even greater difficulties than those which are encountered in the study of the factors which are operative in the causation of the disease in infantile subjects.

Clinical Course.—There is considerable variation in the way in which the disease develops. Some cases are so slight that they are either not noticed at all or are passed over as cases of transient "febricula," due to dentition, to digestive disturbance, or to some one of the many insignificant causes for the transitory upsets of infancy and childhood. Oftentimes a child will go to bed in perfect health, and will be found, on the following morning, to exhibit varying degrees of paralysis, without, perhaps, showing any sign of being constitutionally disturbed. At other times a child will come in from its play complaining of headache, malaise, and febrile symptoms. Upon being put to bed it may drop off into a restless sleep, from which it will awake with inability to use one or both legs or some other part of the body. In still another type of onset the initial symptoms may be such as we have just narrated, but the loss of power may not manifest itself for several days and then only by causing the patient to drag one foot or use it awkwardly in walking or attempting to run. The most severe type is ushered in rather suddenly by fever, running up to 103° or 104° F.; by pain, extending over the entire body, and particularly pronounced when the child is moved; and by headache, drowsiness, hypersensitiveness of the skin, muscular twitching, opisthotonos, and retraction of the head, with occasionally a low grade of delirium and facial paralysis. In a word, these cases strongly resemble those of a beginning cerebro-spinal meningitis. In these febrile cases the body temperature remains high for a week or ten days, sometimes for a still longer period, and comes down by lysis. Hyperæsthesia gradually disappears, and the existence of certain paralyses is recognized sooner or later in the course of the sickness—invariably, in this type, before the patient has been gotten out of bed. Sphincteric paralyses rarely occur in anterior poliomyelitis and are very transient in character. In the Gloucester epidemic two cases were said to have had this form of paralysis. Several months may be required before these patients will recover enough muscular power to enable them to get up and move about even a very little. When paralysis has been fully established it does not long remain at its maximum. In the first few weeks improvement is much more marked than it is during the succeeding weeks and months. This is due to the fact that a considerable amount of the pressure upon the motor ganglia in the anterior horns of the cord is due to the presence of a serous exudate which spreads out from the central area of inflammation in the cord. This inhibits, for the time being, the transmission of nervous impulses through the nerve cells connected with these ganglia, but does not destroy the latter organs. As this serous exudate becomes absorbed, the nerve cells upon which it has been pressing are relieved, and the function of the cell and its neuron is resumed. The complete restoration of certain muscle groups, which at the outset appeared to be completely paralyzed, is to be explained in the foregoing manner. This process of gradual restitution of power goes on for a period of two years in some cases, improvement being due in part to a gradual restitution of functioning power in ganglia inside the zone of serous exudate, and in part to the assumption of power by muscles not before concerned in the performance of the duties of the particular muscular groups paralyzed. Where paralysis remains complete, it is safe to assume that the ganglionic cells at the "storm centre" in the anterior horns were entirely destroyed, and that consequently no restitution is possible in the nerves coming from those ganglia. Under certain conditions not all the nerve filaments contained in a trunk going to some particular muscle are equally compressed; some of the ganglia belonging to these fibres may have been wholly destroyed, while others were only slightly interfered with. It is because of such contingencies as these that it is worth while to keep up massage, passive motion, and other measures designed to promote function in the limb affected by the paralysis. It is quite likely that the few intact nerve fibres contained in the midst of a bundle of fibres, the majority of whose ganglion cells are destroyed, would also lose their conductivity to nervous impulses if the muscles to which they carried stimuli were thrown completely out of function. If, however, effort is made to keep as much of this muscle in action as is possible through passive stimulation, it is likely that some strength may be preserved in a muscle which might otherwise be wholly paralyzed.

Sensory nerves are not concerned in this paralysis, inasmuch as they do not have their origin in the anterior horns. As has been said, the sphincters are not, as a rule, involved, and when by chance they are it is only a transient involvement that has occurred during the acute attack.

Different parts of the cord may be concerned; rarely are all the muscles of the arms, legs, and trunk affected. The lower extremities are more commonly attacked than the upper, and unilateral involvements of the extremities are much more common than bilateral. Irregular distributions of the paralysis are quite common, and, in fact, even in the cases where paralysis is pretty symmetrical, it is the rule to find some muscles which are less completely paralyzed than are their fellows of the opposite limb. In the same limb it is unusual to find flexors and extensors equally balanced. These peculiarities are all readily explicable on the ground that the central zone of the inflammatory exudate marks the point where the greatest injury will be inflicted upon the nerve cells, whereas the periphery of this inflammatory centre will be less affected, and irregular distribution of paralyses, as regards both intensity and area of muscles involved, may be expected. The cervical spine and scapular muscles are frequently the only parts concerned, the arm and forearm muscles not being attacked at all. Rarely the muscles of one arm are concerned. One leg may be wholly paralyzed, or the muscles of the anterior tibial region may be intact, while the posterior ones are paralyzed, and *vice versa*. All kinds of combinations of paralysis may occur in the lower leg. Occasionally the thigh muscles of one side may be affected, and at the same time those of the lower leg of the opposite side. The trunk muscles are more frequently affected at the same time with the leg and thigh muscles than they are separately or simultaneously with the upper extremities alone. When both upper and lower extremities are involved, the trunk muscles generally are also. Irregularity in distribution of paralysis is therefore the rule in anterior poliomyelitis, and it is this fact which is of some importance in enabling one to differentiate between this and other forms of paralysis.

After an acute attack the child soon begins to get about, unless the number of muscles involved is such that locomotion is impossible. In the lighter attacks, as, for example, where only one leg is concerned, and not all the muscles of this, the child soon commences to walk, and recovery is more rapid proportionately, because of this very fact, than in the same grade of paralysis in both lower legs. This is because functional activity is an essential factor in the restoration of a limb to a normal condition. During the stage of degeneration of the nerve fibres there are likely to be soreness and tenderness in the muscles paralyzed and in the main nerve trunks that supply these muscles, but these pass off in a few weeks (three or four), and then it is permissible to commence active treatment. The reflexes at the knee are obliterated in complete paralysis of the lower extremities, and are much diminished in incomplete paralyses. When paralysis is unilateral, loss in reflex is naturally unilateral. The plantar reflexes are also diminished. There is no Babinski phenomenon, as the anterior horns are involved. Too much reliance should not be placed upon the condition of the knee-jerks, because they are so variable and because in infants and young children the obtaining of a reflex is not always possible, even though the reflex mechanism be intact.

Of much greater significance is the flaccid condition which early shows itself in the muscles. They waste very markedly, quite rapidly, and more or less irregularly, according to the degree of the paralysis and the symmetry of its distribution. In some cases atrophy is very marked upon inspection, there being scarcely enough flesh to protect the bones; in other cases, there is not this pronounced emaciation because of the amount of subcutaneous fat. In either case the muscles are flaccid; in the latter the atrophy is chiefly apparent through alteration in the contour of the muscle bellies. Along with the atrophy, and in consequence of it and the resultant impairment of function, local circulation becomes poor—the affected member becomes colder both subjectively and objectively. The blood supply is not directly affected by the paralysis, but a group of paralyzed muscles does not need so much nourishment, and consequently there is set up a compensating endarteritis which regulates the amount of blood brought to the affected limb. As a consequence of this diminution in the blood supply these infantile limbs are frequently subject to "chilblains." They are pale, as a rule, and passively congested over the toes and for some distance up toward the dorsum of the foot. There will also be seen, even on the sides of the calves of the legs, areas which are blue and in some cases almost ulcerated superficially. At a still later stage certain muscles or groups of muscles will show evidences of undergoing contracture. Occasionally paralysis is so equally balanced that the affected part is in equilibrium and no contracture takes place, but this condition is most unusual. The flexor group of muscles are generally the stronger, and if flexors and their opposing extensors are both partially paralyzed it is generally the flexor group which succeed in contracting, by overcoming the less powerful extensors. In complete paralysis it is the anatomical opponent of the paralyzed muscle which contracts, because it no longer meets with a counterbalancing force. The effect of prolonged contracture is to interfere with the function of the contracting muscle, and after a time a partial paralysis of this muscle results. It is for this reason that tenotomy of a long-contracted muscle effects an improvement in its tone and muscular power. A large part of the value of a tenotomy is dependent upon this fact. Correction of the deformity caused by contracture makes it possible for a better function to be established in the non-paralyzed muscle, and therefore the usefulness of the entire limb is thereby enhanced. This is a highly important fact, and it should be borne in mind in all treatment of the deformities of anterior poliomyelitis. One should strive, in every possible way, to secure for the affected limb an approximation to the normal functioning capacity, for it is by this means that the greatest utilization of the muscular power of the partially paralyzed muscles may be gained and that the contracting non-paralyzed muscles may be prevented from becoming in effect powerless. A further result of neglected or inefficiently treated cases of this paralysis is the development of osseous deformities and partial dislocations or subluxations. The usual situations for such complications are the knee, the foot, and the hip; the spine and certain of the smaller articulations of the hands are concerned in the effects of this paralysis at times. The earlier in infancy these paralyses occur the more pronounced will be the osseous disarrangements. Articulating facets are changed and the shape of epiphyses is altered. The internal architecture of the small tarsal bones is changed, and the change in turn effects a transformation in the outward appearance of the bones involved; in fact, they are so altered that they can no longer meet the static conditions which must be satisfied in order to permit of normal function. The impairment of function and compensatory diminution of blood supply interferes with the growth of the paralyzed limb. The more decided are the above-mentioned factors, the more striking is the interference with growth. Such interference is a progressive matter, continuing through the periods of childhood and adolescence. The affected limb falls rapidly behind the non-paralyzed one at those times when normal growth is most rapid. This phenomenon is not probably due to any specific effect upon growth by the disease itself, but is largely due to the effects of the paralysis upon functional activity.

A remote effect of anterior poliomyelitis is static and consists of callosities and inflamed bursæ that develop over points where excessive pressure is being exerted. Ulceration and sometimes even suppuration may take place under these circumstances, thus complicating the paralytic condition very considerably.

Although there is a wide variation in the severity of paralyses in this disease, there has never been observed a case in which, after paralysis has once developed, complete recovery has taken place. There were seen, after the Gloucester epidemic, cases in which there was only the slightest suggestion of a limp, the merest trifle of deformity, and only a slight amount of atrophy, but they were unquestionably cases of anterior poliomyelitis, and, two years after the epidemic in which they occurred, there was demonstrable, though slight, evidence of the nature of the original disorder.

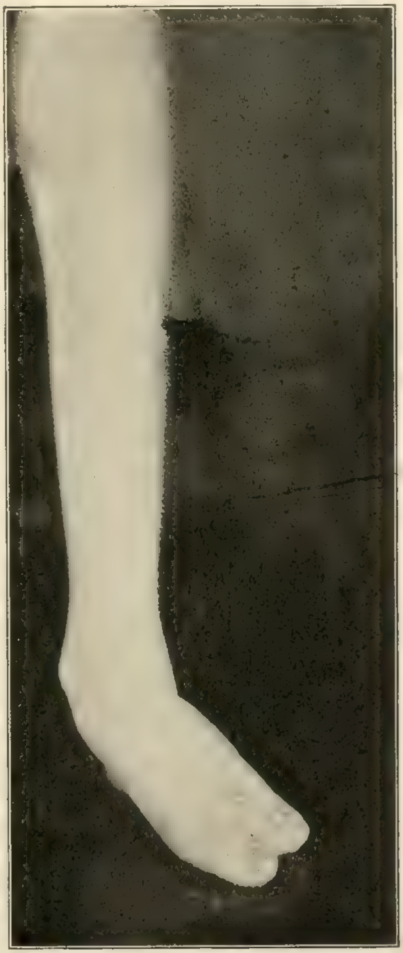


FIG. 582.—Valgus Deformity. Illustrates the abduction of the fore foot and the change in the relation of the long axis of the foot to the long axis of the leg. (Original.)

REGIONS AFFECTED BY THE PARALYSIS.

Lower Extremity.—The commonest situation for infantile deformities is in the lower leg and foot. Anterior poliomyelitis may produce paralysis in any of the muscles of the leg, and, accordingly, we may see every possible variety of club-foot, in correspondence with the particular group of muscles affected. Paralysis of the anterior tibial quite frequently occurs alone, the other muscles of the front of the lower leg remaining intact; the effect of this is to allow the foot to assume a valgus position. (*Vide* Figs. 582 and 583.) When the anterior tibial group is intact and the peroneals and common extensors are paralyzed, we then find the predominant feature to be a varus deformity. (*Vide* Figs. 584 and 585.) If the gastrocnemius group is affected by the paralysis, while the anterior tibial group remains intact, there will develop a deformity of the calcaneus variety. (*Vide* Fig. 586.) These three fundamental positions are in general due to a loss of power, either partial or complete, in the muscle groups just described. When the muscles affected are not closely confined to the fundamental types then we see various combinations—as, for example, a calcaneo-valgus or a calcaneo-varus, a talipes equino-valgus, or a talipes equino-varus. (*Vide* Figs. 587 and 588.)

Under some circumstances we have a partial paralysis of the gastrocnemius group, combined with a loss of power in the intrinsic muscles of the foot and toes, and, as a result of this, the anterior portion of the foot is approximated more closely than normal to the posterior portion, the result of which is to shorten the foot, raise the longitudinal arch, spread out the anterior arch, and flex the toes at the second phalangeal articulations—a combination of conditions to which the name "pes cavus" (*vide* Fig. 587) is commonly given. Sometimes the contracture of the flexors of the toes is the most conspicuous feature of the paralysis, and under such circumstances a paralytic hammer-toe deformity is the prominent feature. (*Vide* Fig. 589.)

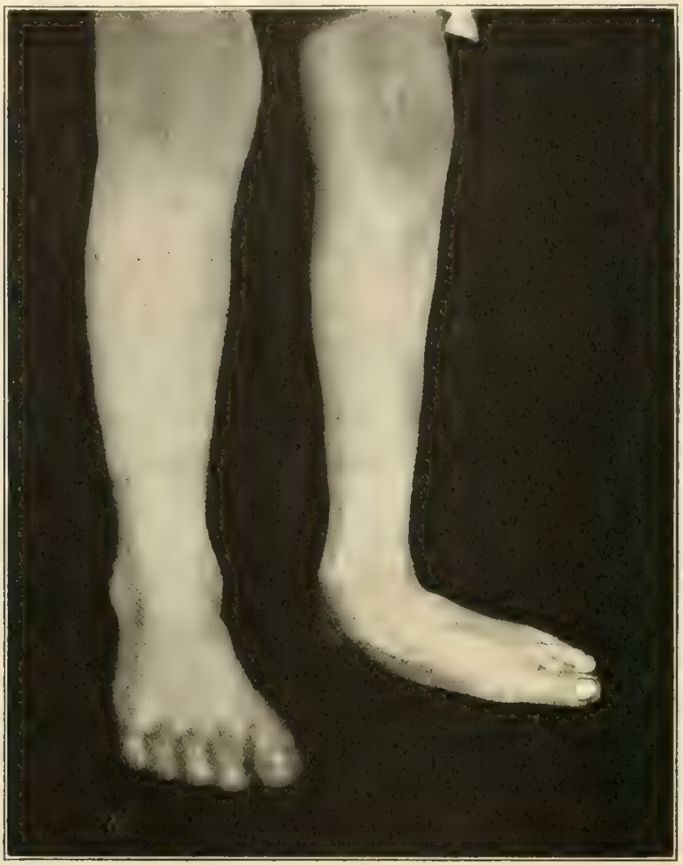


FIG. 583.—Valgus Deformity. Note the atrophy of the calf, particularly of the anterior tibial group, and the extreme degree of valgus. The scaphoid is much nearer the floor than is normal, and the great toe is rotated so that the side of the toe rests on the ground instead of its plantar surface. (Original.)

At the knee joint infantile paralysis gives rise to simple flexion of the knee when the quadriceps extensor is partially paralyzed; when the paralysis is more complete and has been of long standing, and when no measures have been taken to overcome the contracture, subluxation of the tibial upon the femoral condyles takes place. A certain amount of knock-knee is generally combined with the subluxation. If the posterior muscles or the hamstrings are affected, then a genu recurvatum, or extreme hyperextension of the leg upon the thigh, is the result. An unmixed knock-knee deformity in anterior poliomyelitis may occur, but is not usual. Knock-knee deformity is generally associated with rotation of the tibia outward. (*Vide* Fig. 590.) In this type of paralytic deformity there is frequently seen an habitual outward luxation of the patella caused by alteration in the direction of the pull of the quadriceps tendon in consequence of the knock-knee. This condition is also favored by a shallowness of the external trochlear surface of the femoral condyle.

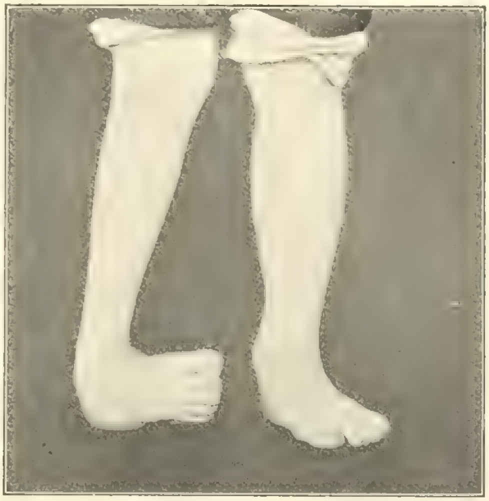


Fig. 584.—Varus Deformity. Note the extreme varus position of the right foot, with the bursa over the cuboid upon which weight is borne. Slight tendency to paralytic valgus is observable in the left foot. (Original.)

At the hip joint, in extreme types of anterior poliomyelitis, a dislocation of the head of the femur may take place. This occasionally gives rise to a condition simulating congenital dislocation of the hip.

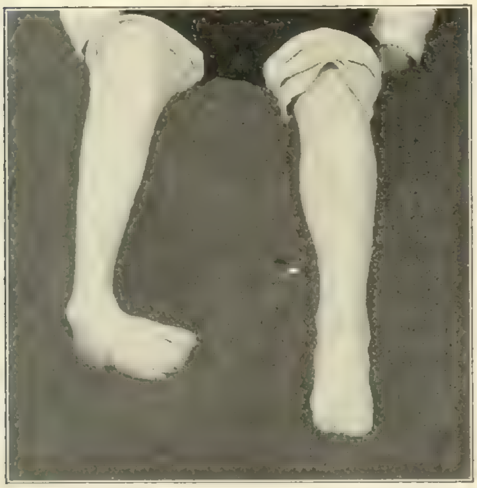


Fig. 585.—Varus Deformity. Illustrates the maximum voluntary correction of varus deformity shown in Fig. 584; also the maximum amount of correction of valgus deformity shown in the same figure. (Original.)

Contracture of the muscles that originate at the anterior superior spine of the ilium may produce flexion of the thigh without causing a dislocation. Contracture of the tensor vaginæ femoris causes an inward rotation of the thigh which produces considerable deformity and consequent disability. Adduction deformity is not as common in infantile paralysis as it is in spastic cerebral paralysis.

Posterior Aspect of the Trunk.—Paralysis of the spinal muscles may give rise to seriously disfiguring deformities. Rotation of the column is a very conspicuous feature of the scoliotic deformity and is dependent upon paralysis. (*Vide* Fig. 591.) Extreme lordosis is sometimes seen in paralyses of the erector spinæ. In paralysis of the muscles of the cervical spine there is no true osseous deformity, but the head is allowed to drop in any direction and cannot be controlled by the patient.

Upper Extremity.—Paralyses of the upper extremities generally concern the shoulder, elbow, and wrist. In the shoulder there are few deformities. Sometimes the head of the humerus is luxated and the arm is rotated in much the same way as it is in obstetrical paralysis. When the extensors of the arm are paralyzed there is permanent flexion of the forearm. Flexion of the wrist and permanent flexion of the fingers, combined with subluxation of the phalanges upon the metacarpals, constitute the most conspicuous of the paralytic deformities of the forearm and hand which are caused by anterior poliomyelitis.

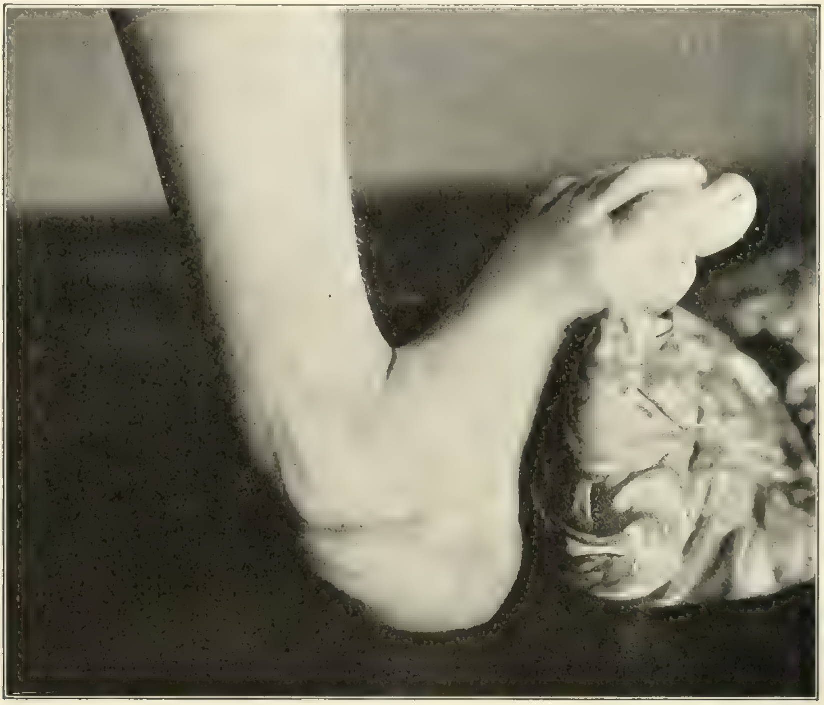


Fig. 586.—In the Picture the Calcaneus Position is Clearly Shown, and the Deep Broad Heel, the Bearing Surface of which is Anterior to the Internal Malleolus, is well Indicated. Flexion of the second row of phalangeal articulations is clearly shown. (Original.)

Dislocations of the peroneal tendons (Fig. 592) frequently occur in infantile paralysis; the posterior tibial tendon is also similarly dislocated. (*Vide* Fig. 593.)

Pathology.—As has been stated, it is rare that cases of anterior poliomyelitis are fatal during the acute attack or in consequence of it. The patients that have died in the acute stage of the disease, and that have come to autopsy, show either distinct inflammatory changes in the neuroglia as well as in the nerve cells or else merely the evidence of thrombosis and embolism. The patients showing the latter condition are those in whom the acute febrile state was not present as a precedent of the paralysis, and they constitute a very small proportion of the total number of cases. In the inflammatory type the neuroglia tissue is infiltrated with serum and a considerable extravasation of red blood corpuscles; leucocytes and round cells invade the area of inflammation abundantly. The ganglion cells become cloudy and granular in appearance, and at a more advanced stage of the process repair commences in the inflamed region, the ganglion cells shrink, the neuroglia cicatrizes, the nerve fibres degenerate, and the entire cord at the seat of the trouble becomes smaller. The effects of this are seen peripherally in muscle, nerve, connective tissue, and blood-vessels. Inasmuch as the sensory nerves are not concerned, the skin rarely gives any evidence of participation in the pathological changes. According to the degree of completeness of paralysis the muscles are found altered. The completely paralyzed muscle is pale, flaccid, and has undergone considerable transformation into fibrous tissue in some cases; in other cases there are evidences that fatty degeneration has taken place. The nerve trunks show more or less complete degeneration; many fibres may be intact or nearly so, showing that the ganglion cells from which they were derived are functioning. Blood-vessels show varying degrees of compensatory endarteritis, but this is not always proportionate to the grade of paralysis present. The changes in the surface temperature always noted in this disease are due to alterations in blood-vessels. In some almost completely paralyzed legs we find an excess of subcutaneous fat, more sometimes than would be accounted for by the nutrition of the patient in other respects. On the other hand, the usual condition is one in which there is practically no subcutaneous fat, fibrous connective tissue having everywhere in great measure taken the place of the normal tissues. Growth is more or less inhibited in these paralytic cases, and this seems to extend to bone as well as to the soft parts. The *x*-ray shows a decided diminution in shadow values of infantile bone, and also reveals the fact that the effect upon bone is not merely related

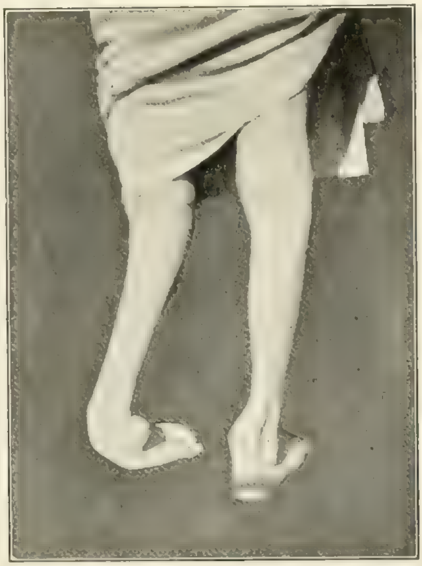


FIG. 587.—Equino-varus Deformity. Illustrates the most extreme type of paralytic equino-varus of the left foot. Note position of the heel and the portion of the foot upon which weight is being borne. There is also a considerable degree of paralytic equino-valgus of the right foot. (Original.)

to its density, but also to its actual size, as shown by comparisons of the paralyzed with the non-paralyzed side. The bone of the paralyzed side is smaller than that of its non-paralyzed fellow.

Physical Examination.—Attention to the physical signs of this disease is of great importance, not merely to enable one to arrive at a conclusion regarding diagnosis, but also to aid one in planning treatment. It is perhaps worth while to spend a little time in going over the physical signs which one meets in this form of paralysis. As has been said previously in this article, the distribution of paralysis may be very irregular, one limb being affected in one part and its fellow in another part; in the same limb one set of muscles may escape entirely, whereas another group, whose innervation is nearly the same, may be wholly or only partially paralyzed. It is this very irregularity in the distribution of paralysis which is suggestive in diagnosis. The flaccid character of the muscles is almost invariably noted. The reflexes at the knee may be wholly obliterated or they may be simply markedly diminished. Often the knee-jerk on one side may be lively or relatively so, while that of its fellow will have entirely disappeared. There is no ankle clonus. A tendency to contracture may manifest itself early. This may not appear on gross examination, but, when attempts are made to put the feet or the knees, for example, through their normal arcs of motion, these tendencies will become manifest. Comparative examinations are always valuable in this connection. It may be that the first sign of this tendency will be noted in the way in which a shoe wears out or runs over. An essential part of the examination of these patients is always the active and passive exercise of the patient's muscles. Much can be learned from this feature of the physical examination. It gives information of diagnostic value and enables the examiner to estimate the quantitative functional values of the paralyzed muscles and how much assistance may be

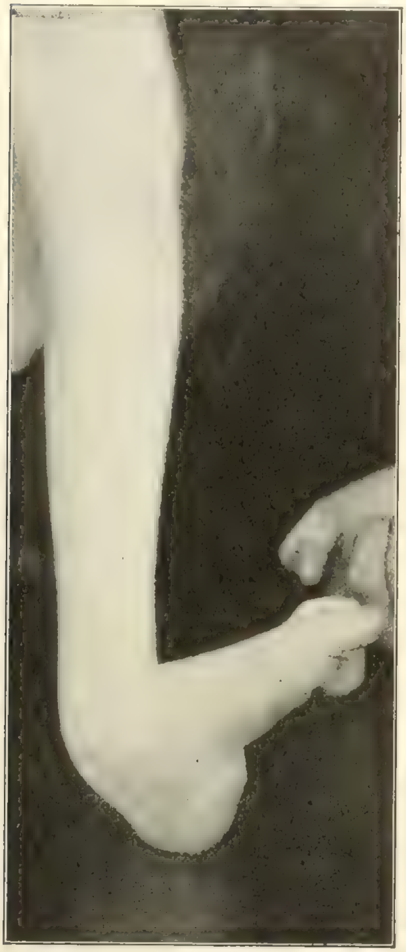


FIG. 588.—Talipes Calcaneus. This figure illustrates the shape of the heel in talipes calcaneus and shows the tendency of the foot in these cases to assume a valgus position in addition to the calcaneus. (Original.)

expected of the partially paralyzed in the performance of the duties expected of them. In cases in which deformity has not declared itself as such, much information of value in preventing its development may be secured by testing the passive motion of joints in the paralyzed region in order to estimate how much, if any, limitation exists and in what direction it is most marked. In such a direction deformity will unquestionably develop, and much may be done to lessen, if not actually prevent, it. When the child is old enough to receive the greatest benefit from tendon transplantation it is old enough to assist in bringing out the information which it is necessary to possess in order to determine what operation is best to employ. For this reason a diminution of the amount of motion and the strength with which such motion can be made in the joints about which muscles are paralyzed is of greater value in most cases than are the electrical reactions. In children the application of electrical tests is difficult, and the results are often indefinite for this reason. In adults or older children they are not necessary. In a muscle affected by infantile paralysis, after the first week has passed, irritability to a faradic current is lost; it preserves its irritability to a galvanic current, but instead of giving its greatest response when the negative pole is closed, as is the case in normal muscle, it yields its greatest reaction upon the closure of the positive pole, and reaction is more tardy than it is in healthy muscular tissue, and is produced only by much more powerful currents than are required in healthy muscle. This is known as the reaction of degeneration and is of more value in determining the possibilities of restoration or preservation of conductivity in paralyzed and partially paralyzed nerve trunks than it is as an aid to diagnosis.

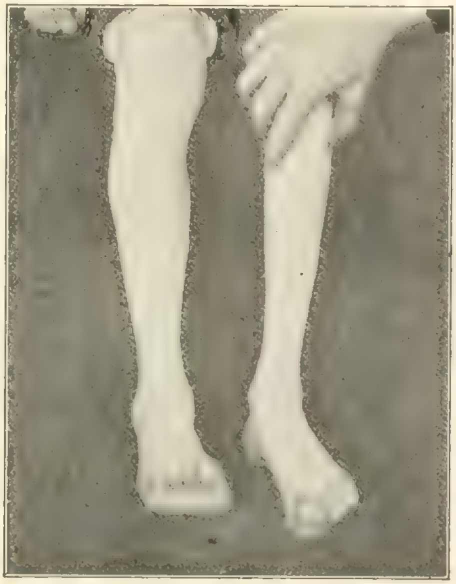


Fig. 589.—Pes Cavus. Illustrates pes cavus in the right foot and pes cavus combined with valgus in the left foot. Note the position of the toes (hammer-toe) and how all the weight is borne upon the ends of the metatarsals; the proximal phalanges are nearly at right angles to the metatarsals. Contracture of the tendo Achillis in both limbs prevents dorsiflexion of the foot beyond a right angle. (Original.)

Differential Diagnosis.—In the average case of anterior poliomyelitis in infancy and childhood, whether in the sporadic or in the epidemic type, there should be no insurmountable difficulties in arriving at a diagnosis. When this disease attacks an adult it is oftentimes an extremely difficult matter to exclude other forms of paralysis. In childhood paralytic symptoms are generally ushered in with a febrile attack, and loss in power is not detected in many cases until convalescence from the fever has been established. Adults, on the other hand, are stricken with paralytic symptoms without any warning in many instances, or, at most, there are only a slight indisposition and malaise for a few days before the loss of motor power takes place. It is in these patients that a diagnosis of peripheral neuritis, transverse myelitis, or even Landry's paralysis is often made.

The three characteristics of anterior poliomyelitis (in the infant) which are most constant and pathognomonic are: (1) Suddenness in the development of acute febrile disturbances, accompanied or shortly followed by (2) a more of less unevenly distributed paralysis; and (3) the disappearance of more or less of the initial paralysis within a comparatively short time, with the persistence of some of it as a permanent legacy. These three clinical signs, if diligently sought for and studied, are usually sufficient for a diagnosis. In addition to them, tests of the reflexes, which are absent in the badly affected limbs, and the determination of the reaction of degeneration in the early weeks of paralysis, afford helpful hints in doubtful cases. The development of deformities, because of inequality in the distribution of paralysis, is very significant.

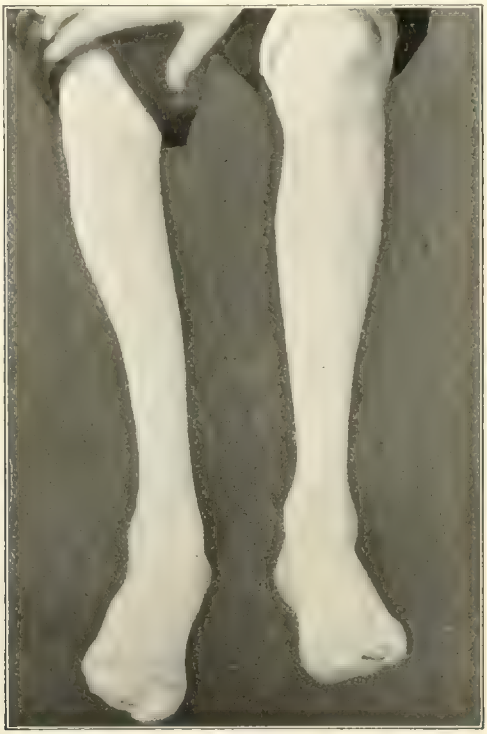


Fig. 590.—The Same Case as that Shown in Fig. 589. Shows the effect of voluntary effort to dorsiflex both feet; the right is pulled into a position of valgus and the equinus is not changed; the left cannot be flexed to a right angle. Hammer-toes in both feet are exaggerated. (Original.)

The more important diseases or deformities from which it is necessary to differentiate anterior poliomyelitis are: Spastic cerebral paralysis in children and transverse myelitis in the adult; Pott's paraplegia, diphtheritic paralysis, obstetrical paralysis, the pseudo-paralyses caused by rickets and scorbutus, multiple neuritis, muscular dystrophies, rheumatism, and joint diseases. Occasionally deformities which are caused by infantile paralysis—as, for example, dislocations of the hips which, though rare, do occur, as the result of the paralysis—are not recognized as being due to this cause. Infantile and congenital club-foot may be confused for a time. Very frequently the lighter attacks of paralysis are overlooked entirely, and a weakened anterior tibial muscle may be a cause for the development of valgus, the reason for which had never been appreciated. In the same way, though with extreme rarity, torticollis may be accounted for. It is of quite as much importance, in these rare instances of the association of deformity with an infantile paralysis as its etiologic factor, that this relation should be recognized as it is in conditions where confusion in diagnosis arises from similarity in symptoms.

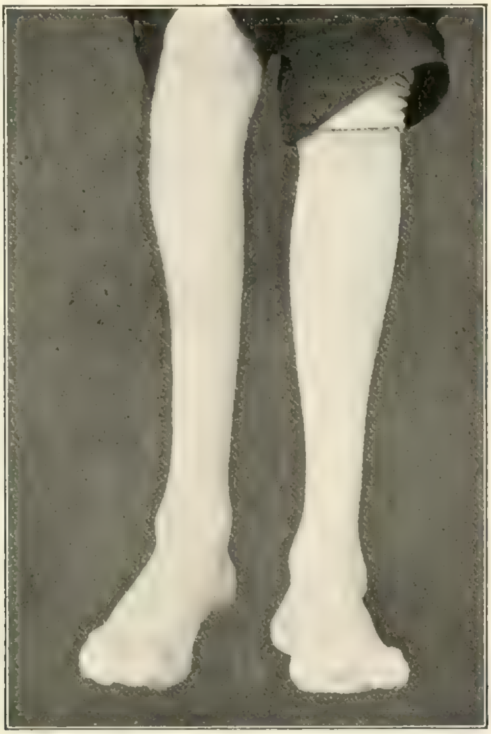


FIG. 591.—**Equinus Deformity.** Note equinus deformity of right foot; atrophy of the calf of the right leg, particularly; and the contraction of all the toes of the right foot with the high instep characteristic of pes cavus. This shows a little more clearly than Fig. 590 does the abnormally high longitudinal arch caused by contracture of the plantar fascia. (Original.)

Spastic Infantile Paralysis.—This condition is usually the result of a birth palsy, and therefore, in the majority of instances, it occurs earlier than do most cases of anterior poliomyelitis. In cerebral paralysis the muscles are in a state of tonic spasm, while the muscle, in a case of infantile paralysis, is flaccid. The tendon reflexes in cerebral paralysis are exaggerated, while they are generally much diminished or wholly absent in infantile paralysis. In most instances spastic paralysis involves the muscles either as a monoplegia, or a diplegia, or a hemiplegia, whereas in infantile paralysis there is much less tendency for the paralysis to be evenly distributed. There are many other fine differential points, but, as a rule, these will suffice.

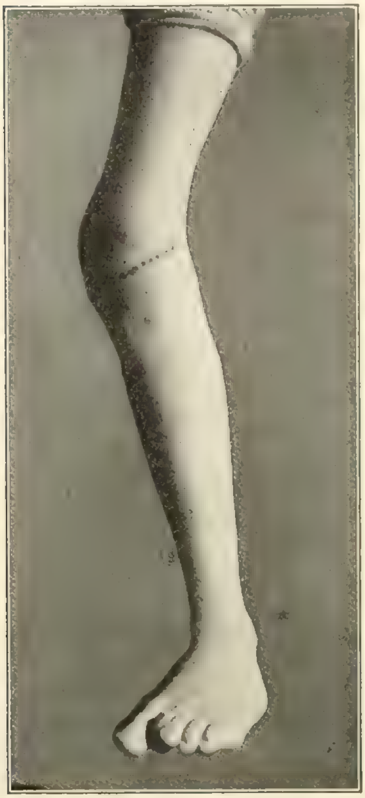


FIG. 592.—Note the Knock-knee Deformity Caused by Paralysis of the Hamstrings. Observe the rotation of the tibia, the angle of inclination of the tibial condyles, and the compensatory varus. (Original.)

Transverse Myelitis.—This is a disease of adult life generally. It is of sudden onset and differs in its manner of commencement from the infantile type of anterior poliomyelitis. Sphincteric involvements and bedsores are very common in transverse myelitis and are practically unknown in infantile paralysis. Sensory disturbances also characterize transverse myelitis, which is not the case in infantile paralysis.

Pott's Paraplegia.—The paralysis or weakness of Pott's disease is almost always characterized by spasticity; rarely is it flaccid. The knee-jerks are generally exaggerated, and there is an ankle clonus in well-marked cases. The presence of a kyphos, or, if this is absent, of rigidity in the spinal muscles, gives a strong intimation of the existence of a tuberculous lesion and pressure upon the cord.

Diphtheritic Paralysis.—It would be difficult to confuse infantile paralysis with this if there had been a frank attack of diphtheria, but the throat symptoms of diphtheria may be very slight and transient, and under such circumstances muscular weakness which showed signs of improvement might cause some confusion for a time. Diphtheritic paralysis, however, entirely clears up, but that due to anterior poliomyelitis never entirely disappears.

Obstetrical Paralysis.—This always concerns one upper extremity, dates from birth, which covers a time when infantile paralysis has not been described as having occurred, and a region of the body rarely affected by it. The characteristic deformity of obstetrical paralysis—viz., the inward rotation of the arm and hand—should be sufficiently characteristic.

Pseudo-paralyses.—In the acute stages of rickets and scorbutus there are great muscular tenderness and pain when the affected parts are handled or when one attempts to move one's self, and in consequence of this muscular tenderness there is loss of power and, in some cases, even temporary paralysis. The signs of the constitutional diathesis should be looked for in rickets, the epiphyseal enlargements, deformities, kyphosis, etc.; and, in scorbutus, subperiosteal hemorrhages and bleeding gums. The active stage of infantile paralysis is characterized by pain in the muscles and soreness when they are handled, but here the similarity stops.

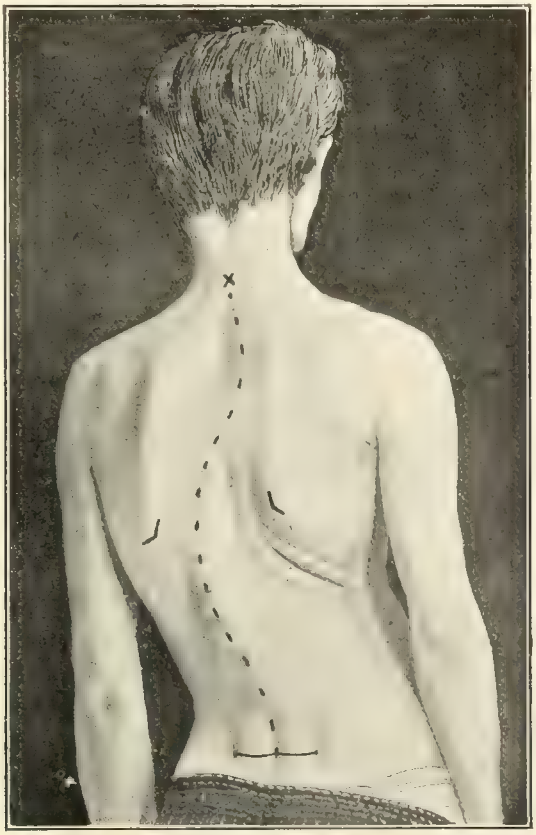


Fig. 593.—Cut Shows the Marked Paralysis of the Erector Spinæ and Quadratus Lumborum Muscles. Note the excellent muscular development of the upper part of the trunk and the narrow spindle waist. The rotation of the vertebræ is quite marked, as is also the lateral deviation of the spinous processes. (Original.)

Multiple Neuritis.—This is of great importance to recognize in the case of adults with symptoms of anterior poliomyelitis. A history of poisoning by some chemical substance, *e.g.*, arsenic, or of a toxic infection after any of the infectious diseases, is suggestive of multiple neuritis. Sensory disturbances along the paths of the nerves are very common and persistent in multiple neuritis. The predilection of the paralysis for the extensor groups and its symmetrical distribution serve to indicate the presence of multiple neuritis rather than of anterior poliomyelitis.

Dystrophy.—The muscular dystrophies are gradual in their development and ought never to be a cause of confusion in the diagnosis of infantile paralysis. There are two types of these: The scapulo-humeral type and the infantile type of Erb, which involves the arms and muscles of the spine. The gradual onset and progressive character of symptoms serve to distinguish this disease from anterior poliomyelitis.

Rheumatism.—There is no likelihood of error in differential diagnosis in this connection except in the early acute stage of these two diseases. When all the muscles are sore and tender to pressure, as they may be in both diseases, and the febrile disturbance is at its height, errors have been made in recognizing infantile paralysis, but when acute symptoms are not succeeded by paralysis there should be no difficulty in diagnosis, and, in case paralysis has succeeded, the indications are clear that a rheumatic diagnosis was incorrect. In this case, as in some others, the only real importance of a right diagnosis is in prognosis. It is obviously unfortunate for the reputation of the physician to diagnosticate the acute stage of infantile paralysis as rheumatism and later on be obliged to account for a paralysis.

Treatment.—The treatment of anterior poliomyelitis must be considered from two points of view. The acute cases have to be cared for, and, though it probably makes but little difference so far as the extent of the paralysis and the ultimate amount of relief afforded are concerned, what measures are adopted, careful nursing will doubtless contribute to the comfort of the patient and may possibly shorten the course of the inflammation. Liquid diet, ice bags to the spine, cold sponging to reduce temperature, and free catharsis should be enjoined during the febrile stage. Massage and electricity should not be commenced until convalescence from the acute period has been well established and muscular soreness has disappeared. The acute stage is a short one, even in the more severe types of disease, and active treatment such as has been outlined does not need to be long continued. Where the infection was a sharp one or the child was not in good condition when the trouble commenced, tonic treatment and out-of-door life should be encouraged as early in convalescence as is practicable.

The measures available for the relief of the chronic cases may be divided into three classes, viz.: physical therapeutics, mechanical therapeutics, and operative treatment. Though all cases may require at some time during their progress all three of these methods of treatment, it is more convenient to consider them separately.

PHYSICAL THERAPEUTICS.

As early as possible after soreness of the muscles has disappeared and the febrile condition has entirely passed, it is proper to commence with physical measures of all sorts. The object of such treatment is to restore as great a degree of power in partially paralyzed muscles as it is possible to secure; to keep up the blood supply to the affected limb to as near that which is required for healthy functioning muscles as is possible; to substitute for the impossible active exercise of the joints, muscles, and tendons an amount of passive exercise which shall in some measure approximate it; to preserve the balance between opposing muscle groups as long as possible by insisting upon motion of joints in which contracture is likely to occur, in order that tenotomy may be forestalled; to prevent the development of deformities, which are disfiguring in themselves and cause permanent impairment of joints through interference with their function. The importance of utilizing motion, however slight it may be, especially when it can be done with the joints in good position, is too little emphasized. The employment of all measures which tend to do this will improve the ultimate result in a given case. In patients in whom the paralysis has selected certain groups of muscles, leaving others intact or nearly so, there is greater tendency to deformity than in the case of a total paralysis of muscles; such conditions require extra effort to prevent deform-

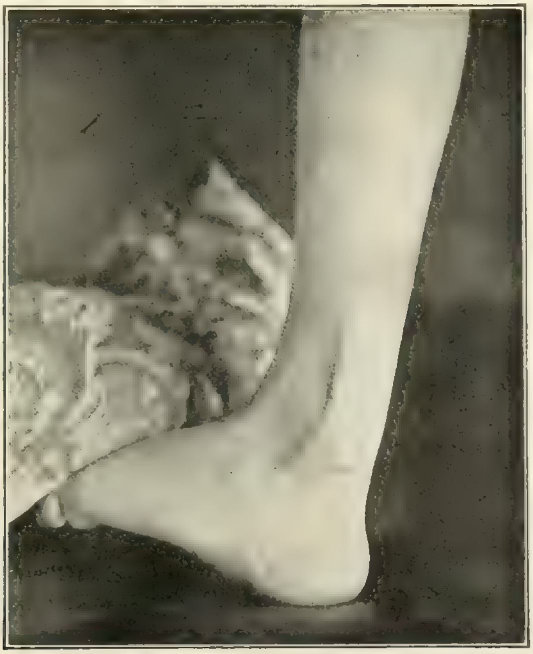


FIG. 594.—Note the Displacement of the Peroneus Longus Tendon over the Anterior Surface of the External Malleolus. The position of the foot is due to paralysis of the posterior calf muscles. Contrast with Fig. 595, which shows the displacement of the posterior tibial. (Original.)

ity. When deformity is allowed to develop, gravity adds its influence to the factors governing the production of distortion.

Massage.—Massage is the measure which is most employed in the treatment of infantile paralysis. Its value is great, but it should be continued much longer than it is generally practised if it is to attain its best results. Any of these procedures must be continued through the growing period of childhood in order to be most effective. The monotony of their practice leads to their being given up, as a rule, just at a time when their greatest efficiency is being demonstrated. Hand massage is all that can usually be obtained, and skilled service of this kind is oftentimes impossible to procure. Mechanical massage has certain advantages over unskilled hand massage, and, where the latter cannot be carried out, mechanical vibrators may be substituted with much benefit. Pendulum apparatus, in the nature of the Zander machines, is of much assistance in stretching out contracting tendons as well as in affording a substitute for voluntary physical exercise. In the neighborhood of the large cities such apparatus is readily available and should be persistently employed. Where it is impossible to have the advantages of such apparatus, passive stretching exercises carried out daily will yield excellent results. Contractures about the feet and ankles, in the popliteal region, and in those tendons which come from the anterior superior spines of the ilium are the ones to which such measures are most applicable.

Electricity.—Electricity has in the past had the widest application of any therapeutic agent, with the possible exception of massage. It has been customary to begin within a few weeks after acute symptoms have ceased, and continue for a year or two. It is probable that it accomplishes a considerable amount of good, but that it is decidedly less beneficial than persistent massage and stretching. The principal benefit to be derived from electricity is in the stimulation of the individual muscle fibres. Very little result is produced upon the circulation of the limb by the use of electricity, and it is the stimulation of the circulation which has the greatest effect upon the growth of the part.

Artificially Produced Hyperæmia.—Active hyperæmia is of much benefit in infantile paralysis. This is best brought about by the application of dry heat. Some form of heater which adapts itself to the shape of the part to be treated should be sought, and the entire affected limb subjected to heat for periods of from twenty minutes to half an hour, three or four times per week. More recently, electric-light baths are being used rather more extensively than the heat of gas-burners or alcohol lamps. The electric ray is thought to have some especial stimulating effect in addition to the benefit attributable to the heat. Where neither of these methods of applying heat is available, a very good though less convenient substitute may be found in the hot pack or fomentation, or by baking in hot sand. The beneficial influence of this treatment upon paralyzed limbs is quickly noticeable in the improvement of circulation. After a few treatments it is frequently noted that the surface temperature and color of the limb remain permanently improved in the intervals between treatments.

Hydrotherapy.—Another method of producing active hyperæmia is by means of showers and sprays of water at different degrees of temperature and under varying degrees of pressure. These are often given in conjunction with the application of heat. The applications are more efficacious the more perfect are the appliances for bringing about the treatment, but the same effects may be secured by homely methods and without expensive paraphernalia.

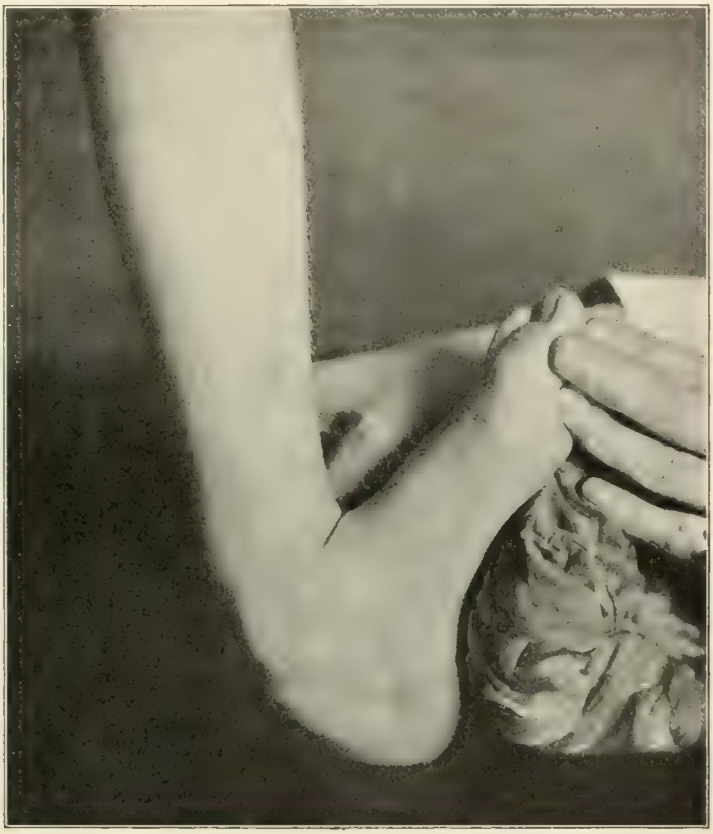


FIG. 595.—Note the Relation of the Internal Malleolus to the Back of the Os Calcis and the Posterior Tibial Tendon. Also note the contracture of the extensor of the great toe and the prominence of the ball of the great toe, a deformity frequently associated with calcaneus. (Original.)

MECHANICAL TREATMENT.

Apparatus is employed in the treatment of anterior poliomyelitis to prevent contractures and consequent deformity and to enable such joints as the ankle and knee to be properly supported in order that the function of the leg may not be more seriously impaired than is made necessary by the loss of power in the muscles which under normal conditions control motion. The tendency has been to apply apparatus in these cases very early, not waiting, oftentimes, for the evidence of contractures and deformity. The joints most frequently concerned are those of the ankle, knee, and hip. Occasionally the spine requires mechanical support. Apparatus should not be applied until there is evidence of the development of deformity when weight is borne; it being assumed, of course, that the measures already prescribed for the purpose of overcoming contractures have been followed out faithfully, though ineffectually. If apparatus is put on too soon, there is much less likelihood that weak muscles will have a good chance to develop to the fullest extent; and function, that most important factor in growth and development, will be interfered with. Patients should, therefore, be seen often enough to render it certain that those who are responsible for carrying out treatment are kept up to their task and that the monotony of this routine is varied as much as may be by the addition of new exercises and the modification of old ones, and also to satisfy one's self that the time for the application of apparatus has not arrived. Contractures develop because of the lack of balance between the stronger and weaker muscle groups, and the mere fact that one strong group is pulling constantly against a weak one tends to make the weak one weaker. There may be considerable power left under such circumstances in a muscle which is seemingly wholly paralyzed. Tenotomy or the use of apparatus so constructed as to relieve tension between unbalanced muscle groups will oftentimes restore power in part to a seemingly paralyzed muscle. The non-paralyzed muscle which is responsible for the overbalancing becomes eventually much weakened because of the physiological disadvantage under which it is laboring. Though the recognition of these facts is of greater significance in planning operative treatment, it is of considerable importance in enabling one to decide upon the proper time for commencing mechanical treatment.

In paralyses affecting the muscles of the calf, plaster of Paris is frequently employed with advantage, especially in the early stages of an equinus. If manual stretching can overcome the tendency to plantar flexion, the foot may be encased in plaster in a position of as great dorsiflexion as can be obtained. In such cases the plaster-of-Paris splint should be made heavy enough for the patient to walk upon, and walking should be encouraged. By changing the plaster at frequent intervals it is often possible to keep the contracture under control and prevent permanent deformity. Eventually, this may be changed to a Taylor club-foot shoe, such as is shown in Fig. 596. In the reverse deformity, viz., calcaneus, the same treatment is applicable, though with less likelihood of a permanently successful result, for the pull of the flexors is then harder to antagonize than that of the extensors. When varus is combined with equinus, and the Taylor shoe is employed to correct it, the upright of the brace should be on the inside of the leg, and there should be a right-angled stop-joint at the ankle so arranged as to prevent plantar flexion of the foot, but permitting dorsiflexion. The foot-plate of the brace should be tilted so as to throw the foot into a position of valgus. If valgus complicates the equinus, the upright should be on the outside of the leg and the arrangement of the stop-joint should be the same and the foot-plate should be so tilted as to throw the foot into a varus position. When calcaneus is the deformity, the upright should be an outside one when valgus is the complicating deformity; and it should be placed upon the inside when it is varus, but the stop should be reversed so that dorsiflexion will be prohibited and plantar flexion be allowed. Such a brace as this is easily constructed, and measurement for it is not particularly difficult. A sole-piece should be cut out of leather board the width of the foot and long enough to extend from the metatarso-phalangeal articulations to the back of the heel. The distance from the sole to the malleolus, outer or inner, according to whether it is to be a varus or a valgus shoe, should then be recorded, and a measurement should also be made of the distance from the sole to the top of the splint, which is just below the knee joint at the maximum circumference of the calf. The circumference of the calf at this point should then be measured. From these measurements

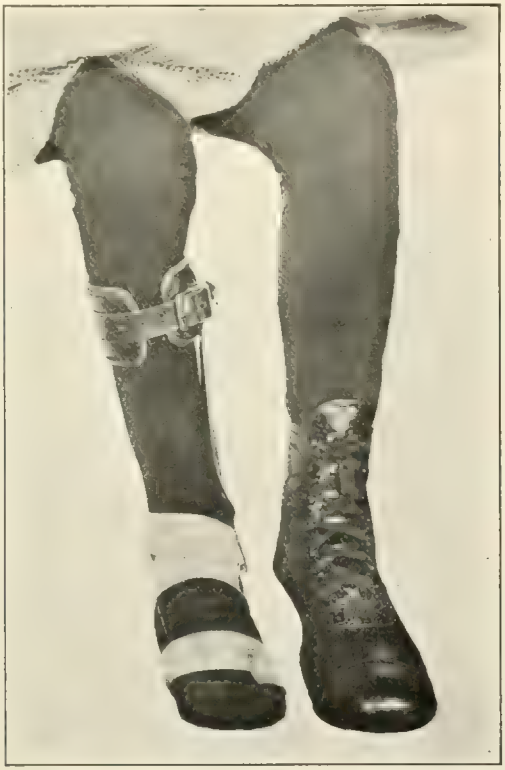


Fig. 596.—Brace for Talipes Equino-varus. The sole-plate does not show. The foot is held on this plate by the straps which cross the dorsum of the foot. There is a right-angled stop-joint to prevent plantar flexion. This is the type of brace used for talipes equino-varus. (Original.)

any competent instrument maker should be able to construct a satisfactory brace. The position of the stop in the ankle joint should also be indicated.

In cases of pes cavus the employment of apparatus is often called for. In this deformity flexion of the proximal phalanges causes the weight to be borne unduly upon the balls of the toes. The result of this is that calluses develop in this situation and on the tops of the toes where the distal end of the proximal phalanx meets the proximal end of the second phalanx. Plates similar to those employed in the relief of flat-foot, particularly the type affecting the anterior arch, lift the weight off these joints, cause the calluses to disappear in some cases, and tend to extend the second upon the third phalanges to a slight degree. Such supports should be fashioned over a plaster cast of the foot and require rather nice adjustment.

When paralysis of the lower leg is accompanied by loss of power in the extensor muscles of the thigh to such a degree that flexion of the leg cannot be prevented when weight is borne upon the extended limb, then an apparatus must be devised which extends from where the Taylor brace for paralysis of the lower leg ends, up to the pelvis. It has to be a much stronger and therefore heavier piece of apparatus. It is made with a "drop-catch" joint at the knee, permitting of easy unlocking of the joint when the patient desires to sit down, and locking of it in the extended position of the leg when he desires to stand or walk. Above the knee to the level of the perineum and below the knee to the calf-band of the leg-piece of the Taylor club-foot shoe there are two uprights. From the top of the thigh-band, which is located at about one inch and a half below the line of the perineum, there is only one upright, on the outer side of the thigh; this continues as far as the greater trochanter, where there is a free joint, and from there it is prolonged to a short pelvic band attached by a free joint to the top of this upright at the level of the anterior superior spine of the ilium. The ends of the pelvic band are joined by a strap encircling the body at this level and buckled into the ends of the pelvic band. In cases of paralysis of both thighs and both legs such an apparatus as that just described is made for each leg. Though heavy and cumbersome, it is possible by its use to enable patients to get about who otherwise would be helpless. They commonly have to use crutches also. It would, of course, be impossible to use such apparatus upon patients in whom there was much deformity. For example, marked contractures of the muscles having their origin at the anterior superior spines or of the hamstrings or of the tendo Achillis, or any very marked degree of knock-knee, would contra-indicate the use of such braces until these contractures had been overcome.

A rarer deformity at the knee is genu recurvatum, and this may require mechanical treatment. The problem in this condition is to prevent hyperextension of the leg at the knee, and a simpler form of apparatus than that just described will suffice in such cases. Paralysis of the lower leg is not so commonly associated with paralytic genu recurvatum. The essential principle in the construction of apparatus suitable for controlling this deformity is the arrangement of the straps and pressure pads in such a manner that the leg cannot extend beyond the point of complete extension. Leather leg splints may be made to answer this purpose where it is impossible to secure the services of an expert instrument maker. A plaster cast of the leg taken in an extended position should be made to serve as a model for the construction of a leather splint, which could be cut in two at the knee joint, and any blacksmith should be able to attach two side steels with a simple joint which could be stopped at complete extension. The construction of infantile apparatus which extends from the sole to the pelvis requires the services of an expert mechanician, and unless properly constructed and carefully fitted it is oftentimes a very unsatisfactory support.

Braces to support the paralytic spine are practically always constructed on the principle of the jacket, usually made of leather. Occasionally aluminum or paper has been employed in their construction. They are moulded over a plaster torso of the individual, in the making of which correction has been made to as great a degree as possible. Paralytic scoliosis is of an extreme type, as a rule, but by extension of the trunk while the model is being taken, and by shaving off parts of the torso after the mould has been filled, considerable correction of the deformity as shown on the model may be effected. A leather jacket built over such a corrected torso will hold the patient in a much better position than his own muscular effort is capable of doing, and thus it is possible to prevent, in a measure, the structural osseous changes which persistence in faulty position is likely to induce in spines affected in this way.

Very many times these spinal paralyses are associated with complete paralysis of the lower limbs, and it is necessary to combine the long infantile leg apparatus with a leather jacket, attaching the two to each other as one apparatus. Even in these extreme cases, by the use of such apparatus, aided by crutches, these patients are gotten into such a condition that they can move about to some extent. Apparatus is rarely necessary in paralysis of this nature in the upper extremities because such paralyses are more rare than in the lower limbs, because they are usually unilateral, and also because the duties usually performed by one hand are easily assumed by the other. Palmar splints to prevent flexion of the wrist and flexion of the fingers are constructed of wire and tin so arranged that each finger has its own separate compartment. Being made of wire it is possible to bend them to suit conditions as they change. In the rare cases in which there is loss of power in the cervical muscles and the head has no support, wire chinrests, such as have been devised for the support of the head in high dorsal and cervical Pott's disease, or the simply constructed Thomas collar, are adequate for this purpose. A Thomas collar is readily made by winding oakum with gauze bandages, making the oakum thickest under the inferior maxilla and tapering it off thin at the back of the neck where it fastens.

OPERATIVE TREATMENT.

In operative treatment we have to consider a great variety of procedures; some of them concern the tendons, some the muscles, some the nerves, and others the joints. A good part of the surgical interference in these conditions is undertaken to correct deformity; other operations have for their purpose the improvement of function by lessening deformity or by securing better mechanical attachments for non-paralyzed muscles. The time for the performance of these various operations is to be determined only through the exercise of a considerable degree of judgment. Patients are generally brought to the surgeon either too early for operation or without having had sufficient conservative treatment to determine whether operation is really necessary or not. They come, having been prepared for the suggestion of operation and having been led to think that conservatism has nothing further to offer. The kind of conservative treatment which has generally been adopted in these cases consists in the unskilled application of electricity and rubbing throughout a period of six months or a year. With such a frame of mind established in the patient or his parents, it is easy to rush into an ill-considered operation. The error in judgment may concern the proper time for interference or the most appropriate procedure. If proper preliminary treatment has been followed, many of the problems in connection with treatment will solve themselves. Tendon transplantations are not as satisfactory when performed in early childhood as they are when deferred until the tenth year at least. As a general rule, if deformity can be prevented or minimized during the growing period (from the fifth to the twelfth or fourteenth year), the patient will have sufficient strength to handle himself fairly well. After this period weight is likely to increase in a ratio out of proportion to muscular strength. Therefore, at this time operations, the purpose of which is to render the equilibrium of the paralyzed limb more stable or to transfer muscular energy in such manner as to make the remaining power more available for function, have their greatest likelihood of success. The determination of when and how to interfere must be a matter to be decided for each individual case, but must not be entered into inconsiderately, because much of the failure which has attended the operative treatment of infantile paralysis and its deformities has been due to such ill-considered interference.

Tenotomy.—Tenotomy is the simplest of the operative procedures employed in the treatment of anterior poliomyelitis. It is performed for the purpose of correcting deformity and to relieve the tension upon contracting tendons whose muscle fibres are not wholly paralyzed, but are overbalanced by their antagonist muscles and are in danger of being completely paralyzed because of the extra stress under which they are laboring. It is not uncommon to witness considerable restoration of power in such muscles after tension is relieved by lengthening their tendons through tenotomy. This operation is performed most frequently upon the tendo Achillis, the hamstrings, both internal and external, upon the tendons which take their origin from the anterior superior spines of the ilium and upon those of the tensor vaginæ femoris and the adductors. It may be accomplished by the subcutaneous method or by open incision. In the region of the tensor vaginæ femoris and the anterior superior spine it should always be done through an open incision. When the adductors are divided it is also best accomplished in this way. As a matter of fact, these last tendons are muscular almost up to the point where they are inserted into the pubic bone, and consequently one usually performs a myotomy when dividing such tendons. The hamstrings, particularly the biceps femoris, had best be seen before they are divided, because of the proximity of important nerves and vessels. The tendon of the biceps is very intimately related to the peroneal nerve, and paralysis of the muscles supplied by that nerve is always a serious matter, and would be particularly so if its muscular supply were the only muscular tissue left intact after an attack of anterior poliomyelitis. In lengthening the tendo Achillis, simple division of the tendon by subcutaneous incision gives as good results in the majority of cases as the more pretentious operations. Orthopedic surgery passed out of the limitations imposed upon it when it was purely the art of treating deformity by means of mechanical devices, after Stromeyer introduced the operation of subcutaneous tenotomy. This was first performed upon the tendo Achillis. When a tendon is divided in this way, even though the separation which is secured between the ends of the tendon amounts to an inch or more, proliferation of the connective-tissue cells in the sheath of the tendon soon bridges over the gap, forming a trellis upon which the more slowly growing tendon soon follows. In paralytic cases the repair is not so rapid as in non-paralytic cases, but firm union is invariably the rule. In order to make tenotomy a more surgical procedure and to avoid the necessity for a complete division of the tendon, various modifications of subcutaneous section of a tendon have been devised. Willett has perfected an operation for tendon lengthening in which he makes a Z-shaped incision in the tendon, and slides the two portions past each other to whatever extent is necessary to correct plantar flexion of the foot. The tendon in this case is sutured with silk or catgut sutures. The Z-shaped incision may be made from within outward (*i.e.*, from in front backward) on the tendon or from side to side. One of the principal cautions to be observed in performing this operation is to avoid having the skin incision come over the line of suture in the tendon. If a subcutaneous skin suture is used, protrusion of the tendon sutures through the skin wound will be prevented, and thus infection of these deeper sutures may be avoided. If they do become infected, the suture will either slough out itself or will have to be removed. In some cases great proliferation of the tendon sheath at the point of section leads to the formation of a tendon callus, which is more or less painful for a considerable time and interferes with the wearing of a shoe because it is pressed upon by the upper of the shoe.

There has also been devised a subcutaneous lengthening operation in which the tendon is not divided all the way across; but this results in the formation of quite a tendinous knot, where the turning back of the tendon upon itself takes place, and has no advantage over other methods.

After tenotomy the parts should be kept fixed in plaster of Paris for from three to six weeks in order to allow the new tendon to form.

Tendon Transplantation.—Since Nicoladoni's early work upon the transferrence of the power of a functionally active muscle to the tendinous insertion of a more or less completely paralyzed one, great advances have been made in the treatment of paralyses due to anterior poliomyelitis. Various modifications of his method have been made from time to time, but they have been concerned chiefly with the technique of the operation and not with the fundamental principles underlying tendon transferrence. As has been the case with every method which has really marked an advance in the practice of surgery, tendon transplantation has been advocated and practised for the relief of conditions for which it was an entirely inadequate procedure. In consequence of this, the operation has fallen into disrepute among many operators. It finds its most successful application in the paralyses of the lower leg, and to a lesser degree in those of the extensors of the thigh. The two methods now most extensively practised are the tendon-to-tendon, or indirect, method (under which there are several minor technical modifications), and the direct subperiosteal implantation. The first of these methods is now most strongly advocated by Vulpius, and the second is known as Lange's method. The accompanying illustrations demonstrate the modifications of the indirect method. (Figs. 597 to 612.) The factors which militate most strongly against the success of the indirect method are: failure completely to overcorrect deformity before undertaking an operation, and, secondly, making the transplantation under too great or too slight tension. If tension is too great, the sutures may cut out, or, if they hold, the transplanted muscle may not be able to act properly because overstretched; on the other hand, if too slight a tension is applied, then the transplanted muscle will use up the most effective part of its contractility in taking up its own slack. In the direct or Lange's method, there is greater liability to sepsis and sloughing. The mechanical advantage, however, is generally greatly in favor of the direct method. Still another cause for lack of success noted in both methods is attributable to a failure to devote time enough and attention enough to the after-care. Too early use of the limb unaided by apparatus is permitted in many cases.

Paralytic valgus deformity is generally due to a loss of power in the anterior tibial group of muscles, more especially in the tibialis anticus itself. (Figs. 613 and 614.) In many such cases the common extensor is intact and oftentimes the long extensor of the great toe is possessed of its full power. The ability to extend the toes is of relatively small importance functionally, as compared with the power to prevent abduction of the foot at the medio-tarsal joint. Good results, therefore, will follow the insertion of the two inner divisions of the common extensor tendon into a slit in the tendon of the tibialis anticus. (*Vide* Figs. 603, 604, 605.) Sometimes the tendon of the extensor longus hallucis may be used to reinforce the common extensors in their task.

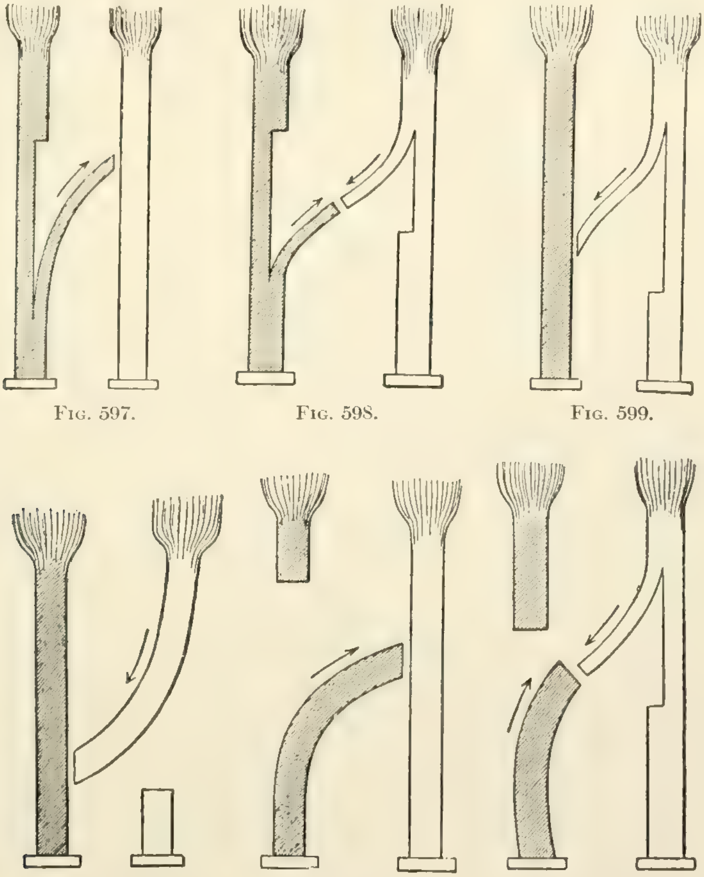


Fig. 597. Fig. 598. Fig. 599.

Fig. 600. Fig. 601. Fig. 602.

Figs. 597–602.—Different Methods of Tendon Transplantation. (Vulpius.) The arrows in these cuts and in Figs. 603–612 indicate the direction in which the muscular power is transmitted. In this and the two following groups of diagrams the non-paralyzed muscle and tendon (the donor) are uniformly left unshaded, while the paralyzed muscle and tendon (the receiver) are shaded.

A preliminary step in this operation should be the overcorrection of any valgus deformity and the retention of the corrected foot in plaster of Paris for a sufficiently long time to insure a thorough stretching out of the non-paralyzed tendons. If this has been accomplished, there should be but little tendency to recurrence of the deformity upon removal of the cast. Then transferrence of the tendon should be done in such a manner that the tendon supplying the power should not be obliged to pull at any greater angle than is absolutely necessary. The implantation should be made under just sufficient tension to produce a slight amount of pull when the foot is held in a slightly overcorrected position. Care should be exercised to cover in this tendon by a sheath of its own. Silk or catgut prepared in some way to render it a little more nonabsorbable than the untreated gut may be used in attaching the tendons to

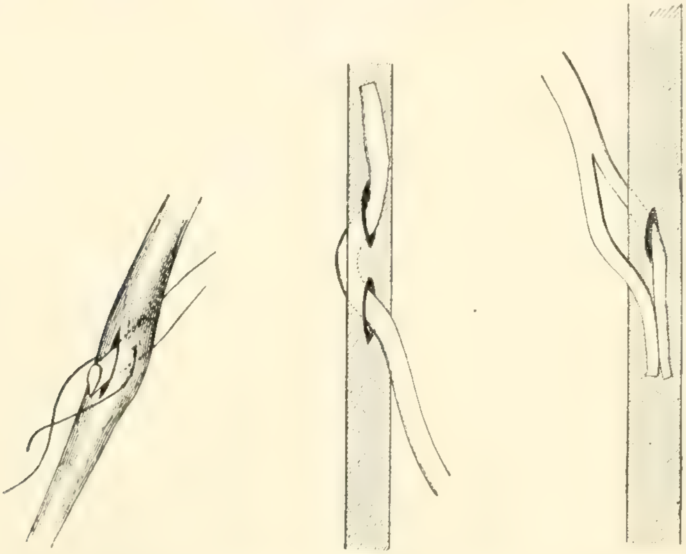


Fig. 603. Fig. 604. Fig. 605.

Figs. 603–605.—Different Methods of Tendon Transplantation. (Vulpius.)

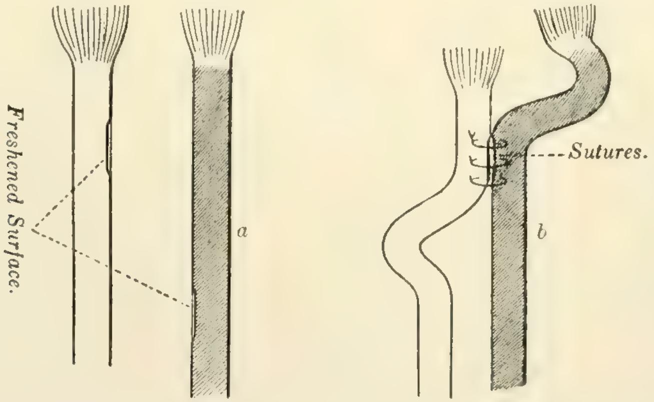


Fig. 606.—A Simple Method of Attaching one Tendon to Another. At *a* the surfaces of the two tendons are freshened and then they are made to unite at these points by means of sutures (*b*). (Vulpius.)

each other. Sometimes a side-to-side, but more commonly a through-and-through, attachment is made. Absolute asepsis is essential to success. A plaster-of-Paris splint applied over a sterile dressing, holding the foot in a slightly overcorrected position, should be kept on for five or six weeks, and should then be succeeded by a Taylor club-foot shoe, with the foot-plate thrown up so that the foot is inclined toward varus. This can be removed for a time each day, and, during this interval, massage, muscle training, and hydrotherapy should be practised. The splint and this routine of treatment should be continued for from six months to a year after the operation. The patient bears weight on the splint unaided by crutches. After the omission of the splint it is better to wear a Thomas lift of a quarter of an inch on the inner border of the heel and sole as a regular addition to the shoe. The inner half of the tendo Achillis may be directly implanted by the subperiosteal method to correct the valgus tendency. The tendon of the posterior tibial may be used in a similar manner. Tendons of similar function to that of the paralyzed one should

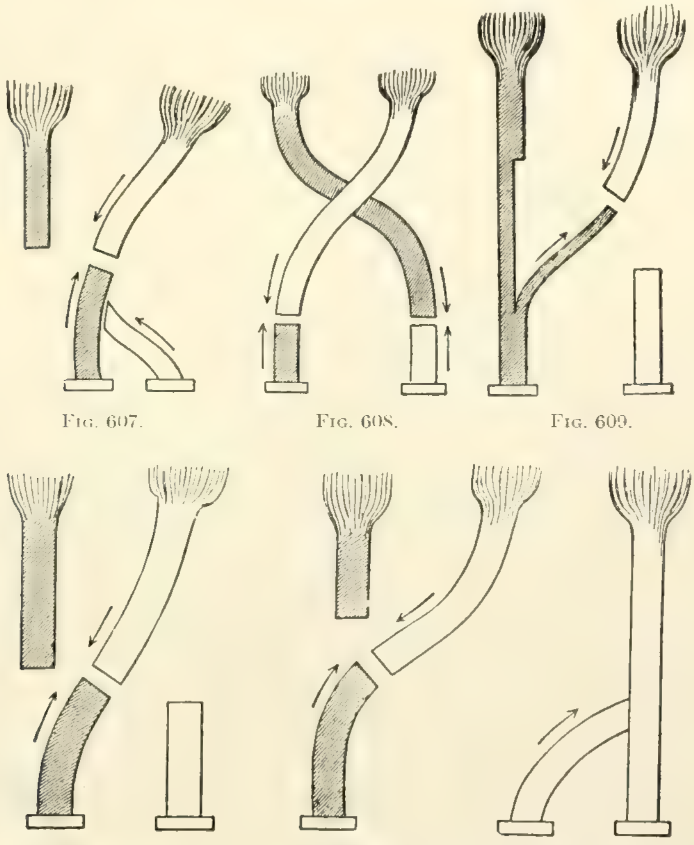


FIG. 607. FIG. 608. FIG. 609.

FIG. 610. FIG. 611 FIG. 612.

FIGS. 607–612.—Diagrams Showing a Variety of Ways in which the Power of a Normal Tendon may be in Part Transferred to one that has Lost its Power. (Vulpius.)

always be used where possible. The employment of extensors to do the work of flexors is not generally successful. This is due in part to the fact that extensors are usually not as strong as flexors and doubtless in part to the mental training—which has been of an unconscious nature, to be sure—that comes from the long performance of the specific actions to which they have been trained. It is for this reason that muscle training should be a part of the after-treatment in all cases of tendon transferrence, and it has been observed that when this training has been associated with the making of the same voluntary motions of the sound side, thus co-ordinating the same groups of muscles, the results obtained have been more satisfactory.

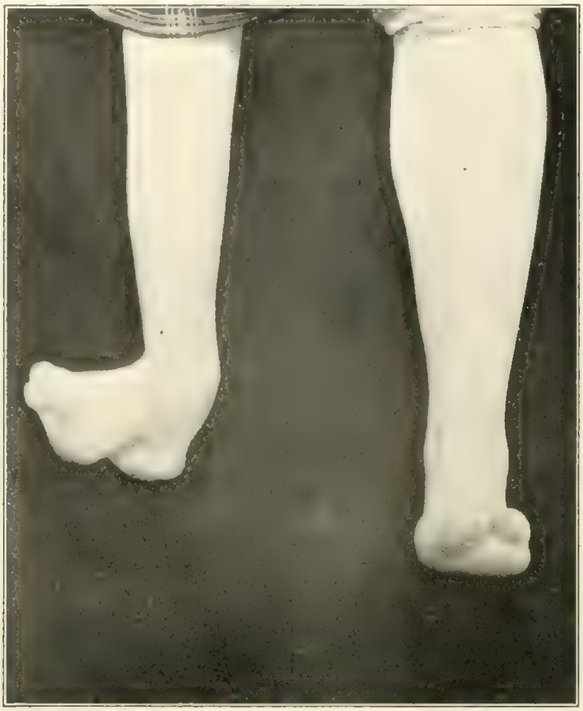


Fig. 613.—Condition of the Feet Before Operation. This cut shows the exaggerated calcaneovalgus produced by voluntary effort to flex the foot dorsally. The anterior tibial muscle is paralyzed, and the unopposed common extensors pull the foot into a valgus position. The same position is assumed when weight is borne. (Original.)

In the treatment of valgus and varus by tendon transplantation it is frequently necessary to lengthen the tendo Achillis in order to be able to correct the deformity; this is, of course, a preliminary step to the operation of tendon grafting. In paralysis of the posterior calf muscles, causing calcaneus as the primary deformity, with either varus or valgus as a contributory factor, it is not uncommon for the peroneals to be left intact, and they may, one or both, be inserted into the tendo Achillis with a steadying effect upon the balance of the foot. It is not fair to expect anything more than this from the employment of this group of muscles. One of the most satisfactory tendon grafts with which the writer has had experience has been the transferrence of a part of the tendon of the tibialis anticus into the tendons of the common extensor, in order to correct varus deformity. The tibialis anticus is a broad strong tendon when its muscle is not paralyzed, and its power may with advantage be divided under such circumstances.

In the region of the knee joint, Lange, who has devised the subperiosteal transplantation, has used silk for transmitting the power of the thigh muscles to a distance; he makes the silk strands act as a sort of trellis over which the tendon may grow, thus eventually covering in the gap that exists between the thigh and the calf. This was found to be necessary when trying to utilize the biceps femoris or the inner hamstrings to take the place of the paralyzed quadriceps extensor. Their tendons are not long enough to be brought up on the front of the thigh and inserted into the patellar tendon; so silk has been used to connect them over the front of the knee with the tibial tubercle. In some cases the sartorius is left when no other thigh muscle is available for transplantation. Its origin in the cord is higher than the usual seat of inflammation, so that it is frequently spared when all other muscles are affected. Though its function is primarily that of a flexor, it can be trained to do good service as an extensor when a proper direction and firm attachment can be secured. In some cases it is efficient enough actually to extend the leg; in others it will serve only to steady the knee and prevent buckling of the leg, to avoid which, if no apparatus is used, the patients are obliged to keep the hand pressed upon the knee.

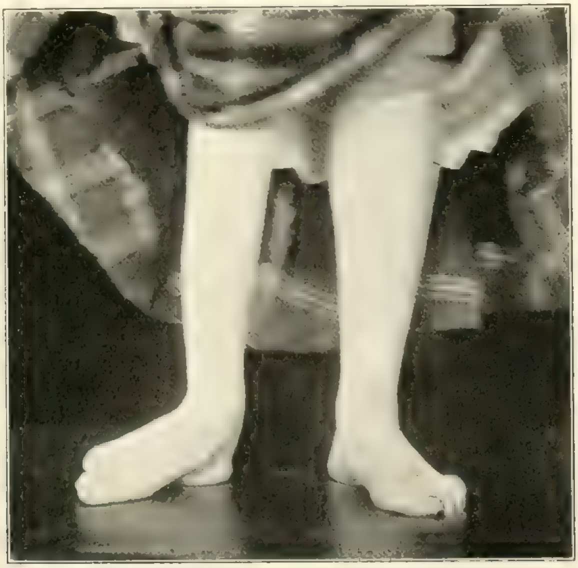


FIG. 614.—Condition of the Feet After Operation (Tendon Transplantation and Arthrodesis.) Shows diminution in valgus over that shown in Fig. 613. (Original.)

It is difficult sometimes to recognize the sartorius in these paralytic cases at the point where the muscle has to be exposed for transplantation. It is displaced in these cases a good deal and looks like the gracilis. By putting the hand upon the anterior superior spine and pulling upon the lower end of the sartorius, it can be demonstrated that it is attached to the anterior spine of the ilium. It is important, in effecting this particular transplantation, to know if the muscle is qualitatively strong, and resort is often had to an examination of the substance of the muscle in order to see if it is of good color and if it responds to mechanical irritation. This test may be utilized with advantage in other muscles where transplantation is contemplated.

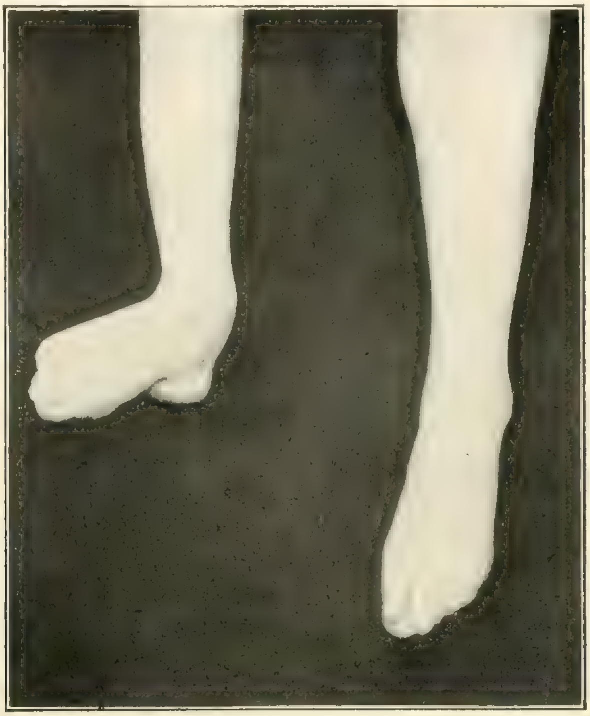


Fig. 615.—This Cut Illustrates the Calcaneo-valgus Position when the Weight is not Borne and Before an Operation for its Relief has been Performed. (Original.)

In the upper extremity very few transplantations are practised for anterior poliomyelitis. In paralysis of the deltoid, Hoffa has effected transplantation of a portion of the trapezius, which has improved the contour of the shoulder and has partially replaced the function of the paralyzed muscle. In the hand or forearm, in cases of paralysis of the flexors, some of the extensors are passed through the interosseous septum and fixed to the paralyzed flexors. Post-operative treatment is very essential to the proper management of infantile operative cases. Protection by splints until tendinous union is solid, and then passive exercises judiciously carried out and muscle-training faithfully practised over long periods make the results more satisfactory and permanent.

Arthrodesis.—When paralysis is complete, or, if not complete, so nearly so that transplantation of tendons is not likely to increase the stability of a joint in its functioning capacity, the possibility of ankylosing that joint must be seriously considered. In many cases, a combination of arthrodesis and tendon transplantation gives better results than either alone. Arthrodesis is practised in the ankle joint or between the bones of the tarsus, in the knee joint, and occasionally at the hip. In the knee joint, tendon transplantation is not combined with arthrodesis. At the ankle, arthrodesis is performed most frequently to correct calcaneus. (Figs. 615 and 616.) In talipes equino-valgus, if there is a possibility of assistance from a tendon transplantation, arthrodesis of the medio-tarsal joint will improve function by adding to the stability of the foot. Arthrodesis of the tibio-astragaloid articulation is the most common of all. It is usually accomplished through an external incision, semilunar in shape and parallel with the peroneal tendons where they pass beneath the external malleolus. (Fig. 617.) After division of these tendons the foot may be dislocated at the tibio-astragaloid joint and the cartilage readily removed from the top of the astragalus, the sides of the malleoli, and the articulating surface of the tibia. The tendons are sutured or transplanted, as the case may be, after the capsule of the joint has been closed and the foot encased in plaster of Paris for from eight to ten weeks. This should be followed by the use of a Taylor shoe for at least six or eight months.

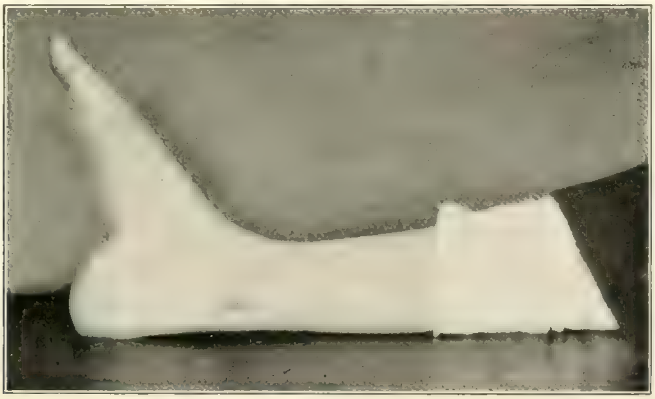


Fig. 616.—Condition of Foot After Operation. Illustrates improvement in calcaneus position after arthrodesis. Foot is now quite firmly ankylosed at the ankle joint in a right-angled position. (Original.)

As a means of remedying one of the defects of this operation, Goldthwait recommeds an osteotomy of the fibula in order to bend in that bone so that it may fit against the lateral aspect of the astragalus. If this is not done there is less firm union than there might be between these two bone surfaces. Solid osseous union is not to be expected, and, as a matter of fact, is not desired. A few degrees of motion at the ankle joint such as a fibrous union would afford is the ideal result. In order that this motion may not be stretched out by too early use of the limb, operative treatment should be followed up by apparatus treatment for the better part of the year. Whitman has advised, in cases of extreme calcaneus, an excision of the astragalus. This enables him to shift the point of bearing of the tibia backward upon the body of the os calcis when he attempts to ankylose it. As a result, there is not the distorted relation of the malleoli to the back of the os calcis which is characteristic of the bad cases of calcaneus. Whitman frequently combines this operation with a transplantation of the peroneals into the os calcis. The results in this operation are best in the adolescent or adult cases, but in younger children they are not so good as an arthrodesis with or without tendon transplantation. Here again the importance of post-operative protection should not be ignored. Arthrodesis at the knee is a very satisfactory operation. By its employment good union invariably follows and there is practically no shortening, for it is not necessary to do a formal excision of the joint; just sufficient cartilage is removed to insure osseous union. Plaster of Paris for from ten to twelve weeks is required before solid union can be expected. During the last two weeks of this time the patient may be permitted, in greater or less degree, to bear weight upon the limbs. One of the chief advantages of arthrodesis in this situation is that it enables the patients to omit the long and cumbersome braces which have been their mainstay in walking. In cases in which both knee and ankle on the same side are concerned, arthrodesis of both ankle and knee has been performed with satisfactory results. In some cases, however, it is necessary

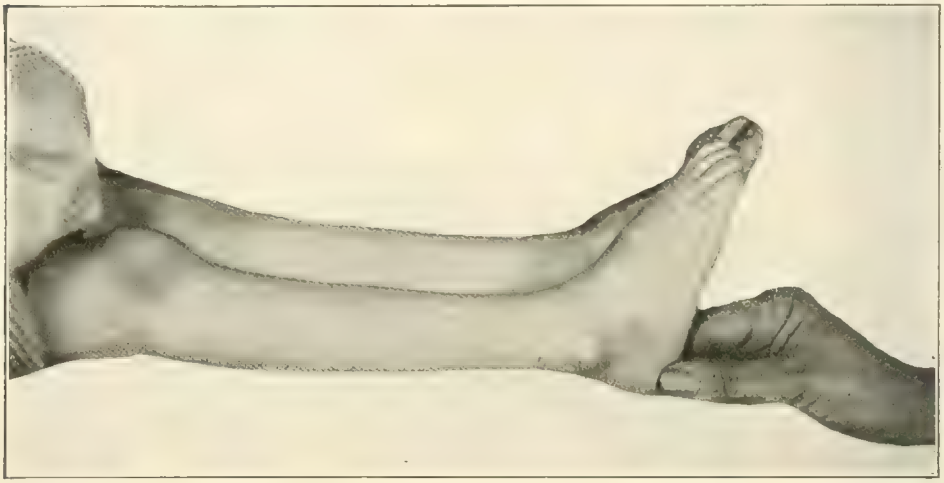


FIG. 617.—This is a Side View of Same Case as that Shown in Fig. 614. Note the atrophy and interference with growth. Patient has had an arthrodesis of the ankle joint. The brace shown in Fig. 596 was worn for six months as a post-operative splint. (Original.)

to ankylose only the knee joint, a short Taylor brace being relied upon in place of the long brace before described. Ankylosing of the hip joint is never done except in the rare cases where the femoral head has become dislocated in the course of an anterior poliomyelitis. It may occasionally be replaced in the acetabulum and allowed to become ankylosed there.

Osteotomy.—Knock-knee of high grade requires osteotomy in some cases. The writer has been obliged to resort to this procedure twice in cases where there was paralysis of the extensors of the thigh, and where at the same time he has effected a transplantation of the sartorius to assume the functions of an extensor. Union of the fracture was not delayed in either case. In one there was, in fact, excessive callus formation. In no other long bone except the femur is osteotomy required for the correction of infantile deformities. In the tarsus, however, it is frequently necessary to osteotomize the neck of the astragalus in the course of the correction of a paralytic club-foot. This osteotomy is generally wedge-shaped. To correct varus it is also occasionally necessary to take out a wedge from the os calcis.

Epiphyseal Irritation.—In some cases of anterior poliomyelitis bony growth seems to be retarded to an extraordinary degree. As the child grows older the leg is noticed to be falling rapidly behind its fellow in growth, in length as well as in circumference. Gunshot wounds of the epiphyses, osteomyelitis involving the epiphyses, and the early stages of tuberculous lesions of the epiphyses are frequently distinguished by an increased growth of bone. Because of these observed facts it has been conceived possible to stimulate growth in the epiphyses of infantile subjects, and this has been attempted by driving ivory pegs into the epiphyses, making careful measurements before operation upon both the well and the paralyzed limb. It is a comparatively simple operation. The bone most easy to peg in this way, and the one where stimulation of growth is most necessary, is the tibia. In the one case in which the writer has had any experience, two cribbage-board pegs were driven into the upper epiphysis of one tibia. These caused no particular discomfort, produced no symptoms, and have remained undisturbed for over two years. There has been no appreciable benefit from the use of pegs in this case. It is a very reasonable method of procedure and should be tried in cases in which failure to keep pace in bony growth has characterized the course of an infantile paralysis.

Nerve Transplantation.—Since it has been demonstrated that regeneration of nerve power can be brought about by the implantation of an active, living, and conducting nerve trunk into a paralyzed one, incentive has been given to attempts to transplant nerves in order to bring power back to paralyzed muscles. Cushing's work upon the transplantation of fibres of the spinal accessory into the facial in order to relieve facial paralysis has added much interest to this problem in connection with infantile paralysis. Spitzy, of Graz, has carried out a considerable series of experiments to determine the possibility of the procedure in animals, and has made a few applications of the principle to the human subject with a considerable degree of success. In both the dog and the human being he worked with the peroneal nerve. In this country, Young, of Philadelphia, has made one such transplantation. In one case which has not as yet gotten into the literature, the sciatic was completely divided by the knife high up in the thigh and the distal portion of the nerve was rotated one-half way round and held by sutures through the sheath in an attempt to approximate the fibres coursing in this trunk to the extensor longus hallucis, to some other fibres that might be stimulated to supply muscles of greater importance to the function of the foot than the long extensor of the great toe. This was undertaken purely as an experimental study in a case in which its failure could cause no harm. It was attended by no appreciable beneficial result.

So far, experience with nerve transplantation, though suggestive, has not yielded any very brilliant practical results. It is a rational method and it may be shown eventually that certain cases are treated better in this way than by any other procedure, just as it has been shown that arthrodesis is better in some cases than tendon transplantation, and *vice versa*. The discovery of new methods is always attended by an amount of enthusiasm and a widespread application which subsequent results and saner judgment do not always justify. Failure is quite as frequently the result of not knowing when and how to use a method as it is of a defect in the method itself. It is generally safe to infer that, if some result has attended the application of the new principle in the hands of a carefully trained observer, there is some value to the method, although its universal application must not be inferred. It is to be hoped, therefore, that those who have the opportunity and the clinical material upon which to follow out this lead of Spitzy will do so, as there seems much of promise in it. (See also Dr. Willard's article in Vol. II.)

Prognosis.—The outcome of an acute case of infantile paralysis is rarely in question as regards the continuance of existence. In some of the larger epidemics reported there have been a few deaths. In the Gloucester epidemic there was recorded at that time one death in the case of a patient who seemed to have had spinal paralysis and in whom cerebral symptoms were very pronounced. As there was no autopsy the diagnosis has never been absolutely sure. It may have been a sporadic case of cerebro-spinal meningitis, the diagnosis of which has generally been made in the mortuary records of Gloucester two or three times each year for a number of years previous to 1900, the date of the infantile epidemic. Death in the sporadic cases is very rare indeed. Prognosis as to restoration of function is a very hard matter to offer positive information upon. During the acute attack and after paralysis has declared itself, much comfort can be given the patient's family by assuring them that the loss in power is not going to be progressive or as complete as it then may be. In other words, considerable improvement may be expected, though it will be gradual. When recovery has commenced, it is again reassuring to know that it is likely to continue for at least a year, and that even without treatment progression toward an improvement over the condition at the time of the onset of the attack is confidently to be expected. Parents and patients should be told that it is impossible to determine at the outset how complete the return of power in a given muscle is likely to be. After it is possible to apply the electrical tests, valuable information may be had as to the possibilities of restoration of power in the nerves supplying the paralyzed muscles. At the expiration of a year or two after the onset of paralysis it is usually possible to give a more definite prognosis regarding how much improvement in function is to be expected from treatment, mechanical and operative. This should be based upon the extent of the loss of power in the paralyzed muscle groups, the distribution of the paralyzed muscles with especial reference to the deformities which they seem to favor, the weight of the patient, and the feasibility of the transplantation of muscles whose intrinsic strength and adaptability are great enough to be used in replacing the loss of power effected by the paralysis.

Temperamental peculiarities in the patient and the presence of opportunity for adequate treatment other than operative must be given weight in offering a prognosis. Even in the bad cases the outlook is not as hopeless as it oftentimes seems. Fortunately, anterior poliomyelitis does not affect the cerebrum, so that mental weakness or imbecility does not accompany the paralysis. An assurance to the patient or parents that infantile differs is this respect from the spastic paralysis of childhood is often comforting.

DEFORMITIES AND DISABILITIES OF THE LOWER EXTREMITIES.

By ROYAL WHITMAN, M.D., New York City.

I. COXA VARA.

Depression of the Neck of the Femur.

Coxa vara is a term that signifies depression of the neck of the femur, and, although it is not particularly descriptive, it serves to call attention to the fact that coxa vara is one of the so-called static deformities, such as genu varum and valgum and the like, which are caused in most instances by the weight and strain of functional use upon parts that are incompetent to sustain it.

Thus, although the neck of the femur may be depressed as the result of acute or chronic disease at the joint or in the neighborhood of the trochanter, or induced by ostitis deformans or osteomalacia, distortions of this character incidental to disease are not properly included under a title that implies simple deformity.

Etiology.—Coxa vara may be caused directly by injury (fracture); it may be congenital, in which case it is usually accompanied by other distortions; and, in a slight degree, it is often present in congenital dislocation of the hip. In the majority of cases, however, as has been stated, its etiology is similar to that of the more familiar deformities of the bones of the lower extremity.

Thus the most important of the predisposing causes is rhachitis, which directly weakens the structure of the bone, the exciting causes being over-weight, over-strain, or injury.

The common rhachitic distortions of the limbs are self-evident, and they usually appear, or become exaggerated to more extreme deformity, when the child begins to walk. Coxa vara, on the other hand, is far less likely to cause symptoms at this age, because the neck of the femur is very short and is therefore not exposed to direct strain. In fact, the lessened angle in this class of cases is more often due to the outward bending of the upper part of the shaft of the femur than to the direct depression of the neck itself, and, although such depression of slight degree, direct or indirect, is often present in rhachitic children, as may be proved by *x*-ray pictures or demonstrated by physical examination, it is usually so masked by other distortions of the limb that its diagnosis is made only by those who are searching for it.

If, then, the statistics of coxa vara be limited to the class in which the deformity causes symptoms sufficiently marked to demand treatment, it will appear very decidedly as an affection of late childhood and adolescence. It is more common in males than in females and far more often unilateral than bilateral.

Thus, of 72 cases that have come under my personal observation, 46 were in males and 26 in females. In 59 cases the deformity was unilateral (32 R., 27 L.); it was bilateral in 13. Forty of the patients were adolescents, 12 to 17 years of age. Twenty-three were in late childhood, 5 to 12 years. Six were older than 17, and three were less than 5 years of age.

In many instances the symptoms had persisted for years, but, due allowance being made for this, it may be stated that in more than half the cases the symptoms did not appear until adolescence, and that in at least three-quarters of all the cases the period of early childhood had been passed.

As far, then, as etiology of the characteristic cases is concerned one may consider rhachitis as more often a predisposing than a direct cause, in that the neck of the femur, slightly depressed in early life (latent coxa vara) (Fig. 618, 1), is, by reason of the lessened angle, subjected to greater strain in adolescence, a period of weakness when growth is rapid, when the part is more exposed to direct injury, and when laborious occupations are begun.

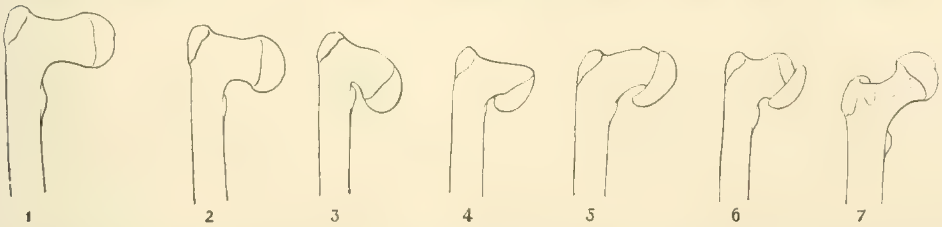


Fig. 618.—Types of Coxa Vara. 1, Depression of the neck caused in part by outward bowing of the shaft—the ordinary rhachitic form, usually bilateral, which, in childhood, does not cause, as a rule, direct symptoms; 2, simple depression—cervical coxa vara; 3, more extreme deformity of the same type; 4, cervical coxa vara, combined with more extreme deformity at the epiphyseal junction; 5, epiphyseal coxa vara—deformity at the epiphyseal junction, without depression of the neck, usually traumatic; 6, epiphyseal disjunction; 7, normal contour.

Abnormal weakness of structure, or disproportionate weight or strain, and, above all, direct injury are contributing or exciting causes. Many writers have assumed that the deformity may be explained by a peculiar primary softening of the bone (local osteomalacia), but investigations have shown no evidence of such disease, the changes being such as might readily be explained by progressive deformity and by the local disturbance of nutrition induced by it.

There are two characteristic types of coxa vara: in one the neck is depressed as a whole, there being simply a change in the angle between the shaft and the neck (cervical coxa vara), a form more common in childhood as the direct result of rhachitis (Fig. 618, 2); in the other, the deformity is most marked in the newly formed bone at the junction of the head and neck, the head (Fig. 618, 4) in extreme cases being, as it were, turned backward and under the neck. This may be classed as epiphyseal coxa vara. (Fig. 618, 5.) It is more common in adolescence and it is often caused directly by injury. In such cases it is in reality partial epiphyseal fracture. In a certain proportion of these cases previous depression of the femoral neck, the result of infantile rhachitis, serves as a predisposing cause.

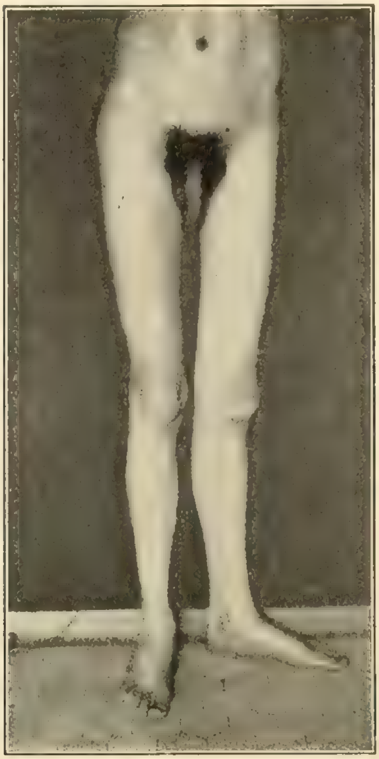


FIG. 619.

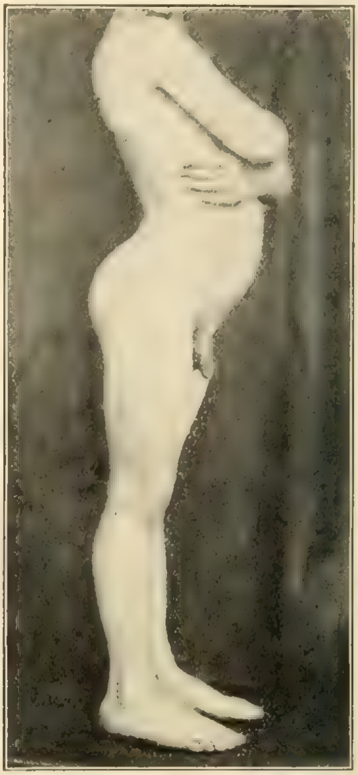


FIG. 620.

FIG. 619.—Right Coxa Vara in an Adolescent. The prominence of the trochanter and the outward rotation of the limb are shown. There is no evidence of former rhachitis.

FIG. 620.—Bilateral Coxa Vara of the Anterior Form, showing Exaggerated Lordosis. An uncommon type that resembles congenital dislocation of the hips. In this form evidences of former rhachitis are usually apparent.

Occasionally the neck of the femur is depressed, its normal lateral relation to the shaft being retained, but in most instances it is turned backward. In the progress of the deformity there is, as it were, an impaction of the posterior and weaker surface, so that the anterior border of the neck becomes somewhat convex.

PHYSICAL EFFECTS OF THE DEFORMITY.—As the range of motion at the joint and the attitude of the limb are dependent on the normal relations of the component bones at the articulation, any change in these relations must induce a corresponding change in function. For example, the range of abduction (45°–55°) is dependent upon the normal upward inclination of the neck of the femur (about 128°), being finally checked when the upper border of the neck comes into contact with the outer border of the acetabulum. If, therefore, the neck of the femur is depressed, abduction is limited in corresponding degree. As the neck of the femur is usually turned backward the effect is, as in impacted fracture, to cause outward rotation of the shaft of the femur. Flexion is limited by the contact of the neck of the femur with the anterior border of the acetabulum, while the range of extension is often increased. Thus, the physical effects of ordinary coxa vara are shortening and outward rotation of the limb, the range of motion at the joint being limited in abduction, inward rotation, and flexion. In bilateral coxa vara of this type, as both trochanters are carried forward by the backward displacement of the femoral necks, the lumbar lordosis is diminished. If, however, there is simple direct depression, or if the femoral necks are turned forward, the lordosis is increased.

In cervical coxa vara the function of the joint is impaired principally by the deformity and in the manner described, but in epiphyseal coxa vara, in which the articulation is partly disorganized, motion is usually far more limited, particularly by muscular spasm and contraction. Partial traumatic separation of the head of the femur, not uncommon in adolescents, resembles the epiphyseal type of coxa vara so closely that it can be differentiated only by the history. It may be stated also that in any form of coxa vara the lessened angle of the neck weakens it and predisposes to further injury. Thus partial or complete fracture of the neck or epiphyseal separation not unfrequently complicates the deformity. In such cases the patient, who may have limped slightly for several months, becomes suddenly disabled after injury or overstrain. Pain is usually marked on motion and the joint may be practically fixed by muscular spasm. It may be of interest to note in this connection that there have come under my observation thirty-four cases of fracture of the neck of the femur in young subjects, in eight of which the injury was apparently at the epiphyseal junction.

Symptoms.—The symptoms of coxa vara are indicated by the description of the physical signs. They vary with the degree of deformity and the rate of its progression and they are, of course, aggravated by strain and injury.

The most suggestive symptom is a persistent limp. This is accompanied usually by sensations of weakness, of discomfort referred to the thigh, and stiffness on changing from a state of rest to one of activity. On examination one notes the following changes: the actual shortening due to elevation of the trochanter, and in well-marked cases the apparent shortening caused by the upward tilting of the pelvis, in compensation for the limitation of abduction; the outward rotation of the limb; and the peculiar and unequal limitation of motion. If the weakened part has been injured or strained, more or less intense muscular spasm may still further limit motion. This is more often present in the epiphyseal type of deformity, which is, as has been stated, in many instances an incomplete fracture.

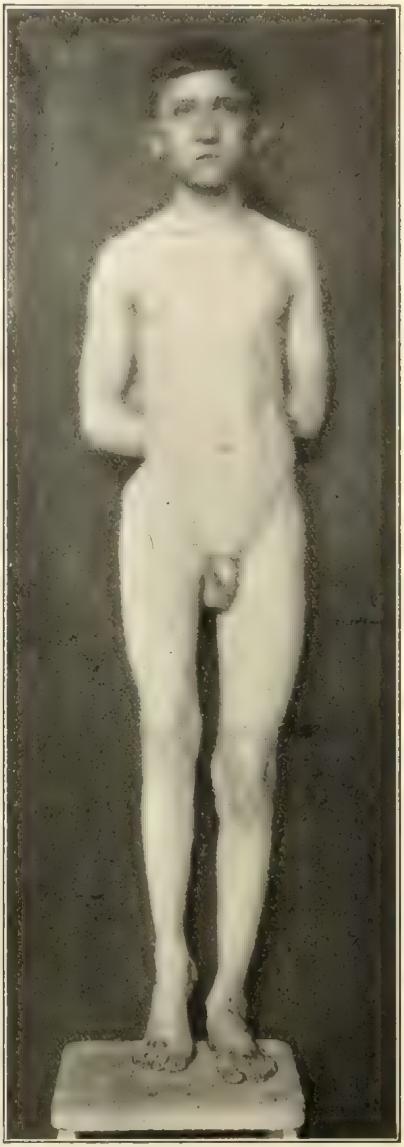


Fig. 621.—Right Coxa Vara, Illustrating the Actual and the Apparent Shortening of the Limb in Advanced Deformity of the Traumatic Type. (Original.)

In bilateral coxa vara the symptoms as regards each limb are the same, but the effect on the individual is more marked. The double limp causes a swaying gait and, as has been stated, the normal lordosis is diminished. In extreme cases the adduction of the thighs may make locomotion difficult.

Diagnosis.—Knowledge of the nature and effects of coxa vara should make the diagnosis easy. It is most often mistaken for congenital dislocation of the hip and for hip disease. The first affection is congenital, while coxa vara is acquired. This alone should be sufficiently diagnostic in most cases. In congenital dislocation, if the thigh be flexed and adducted, the head and neck of the femur can be palpated, while in coxa vara nothing but the trochanter is apparent. In coxa vara actual shortening is present from the first, while in hip disease this is a late symptom. In coxa vara motion is limited by the deformity, particularly in certain directions, the range of extension remaining unrestricted. In tuberculous disease all motions are limited, particularly extension. Strains or other affections of like character are not accompanied by shortening and could not therefore explain the symptoms. Incomplete or impacted fracture of the neck is traumatic coxa vara, its cause being, as a rule, apparent in the history.

It has been stated that the mild degrees of coxa vara would be often found among rhachitic children if it were looked for. It is usually bilateral, its chief symptoms being outward rotation of the limbs and limitation of abduction at the hips. It is usually accompanied by bowing of the limbs rather than by knock-knee.

In conclusion, it may be stated that an *x*-ray picture will in doubtful cases make the diagnosis clear, and by this means one may often distinguish the varieties of the deformity that have been mentioned.

TREATMENT.—The prevention of coxa vara might include the treatment of infantile rhachitis. If coxa vara is present at this early age one should attempt to correct the distortion of the neck by methodical manipulation of the limb, particularly in inward rotation and abduction, with the aim of improving the attitudes and overcoming restriction of motion at the hip joint.

If the diagnosis of unilateral coxa vara is made early, the progression of the deformity might be prevented by a form of convalescent hip splint after the Taylor model which will transfer the weight to the perineum until the internal structure of the neck, softened during the progression of the deformity, may have become stable. Meanwhile the nutrition may be improved by exercises and massage of the limb and by forcible manipulations in the directions in which movements are limited. This is particularly indicated because the direct effects of the deformity are always increased by muscular adaptation. Horseback and bicycle exercise are to be recommended also.

This treatment should be continued for at least a year and long standing or other strain must be avoided for a longer period. If the deformity is bilateral, direct support can hardly be applied. In certain cases of the progressive type, whether unilateral or bilateral, the writer's operation for the correction of impacted or incomplete fracture—namely, forcible abduction at the hip—may be of service. The patient being anæsthetized, the limb is first abducted until the outer border of the depressed neck comes into contact with the upper border of the acetabulum. Further abduction, the head of the femur being held in the acetabulum, brings direct pressure against the resisting neck. In recent fractures the deformity may be corrected by forcing the limb to the limit of abduction, and doubtless, if the structure of the neck were yielding, as in rapidly progressing deformity, the same result might be accom-

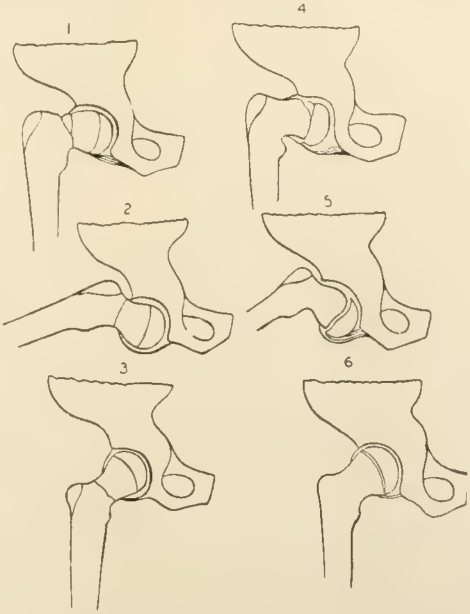


FIG. 622.—Fracture of the Neck and Separation of the Epiphysis of the Femur. (Whitman's "Orthopedic Surgery.") 1, Fracture of the neck of the femur; 2, restoration of the normal angle by forcible abduction; 3, the limb in normal position; 4, 5, and 6 illustrate separation of the epiphysis of the head of the femur treated by the same method.

plished. In any event, the stretching of the contracted adductor group of muscles should be of service in improving function. (Fig. 622.)

Attention may be called again to the fact that the deformity of coxa vara is of the group that includes the more familiar distortions of the bones of the lower extremity, and it may be treated in the same manner, namely, by direct operative correction of the deformity. The object is, of course, to replace the neck in the proper relation to the shaft, with the aim of restoring function and removing abnormal strain. For this purpose I have found the following operation to be most efficacious, particularly in those cases in which outward rotation is not extreme. The patient having been anæsthetized, the muscular contraction is overcome by vigorous stretching until abduction is free to the point at which it is restricted by contact of the outer part of the neck with the upper border of the acetabulum. An incision, about three inches in length, is then made from a point about an inch from the apex of the trochanter directly downward in the line of the shaft. The bone is then thoroughly exposed and a wedge, at the base about three-quarters of an inch in breadth, is removed, the apex being directly opposite the trochanter minor at a point about two inches from the upper extremity of the trochanter. The upper section should be practically at a right angle with the shaft, the obliquity being entirely in the lower portion. Sufficient of the cortical substance of the inner aspect of the bone, reinforced by the cartilaginous trochanter minor, is allowed to remain to preserve the continuity of the bone. The limb is then gently ab-

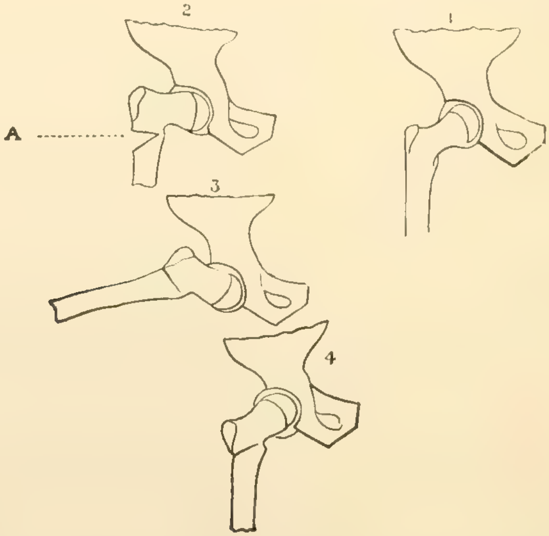


Fig. 623.—Illustrates the Operative Reduction of the Deformity of Coxa Vara. 1, The normal contour; 2, depression of the neck of the bone (coxa vara) (at *A* a wedge of bone has been removed); 3, abduction of the limb first fixes the upper segment by contact with the rim of the acetabulum, then closes the opening in the bone; 4, replacement of the limb after union is completed elevates the neck to its former position.

ducted until the wedge-shaped opening is closed, the inner part of the bone bending like a hinge without fracturing, so that there is no danger of displacement of the fragments. If the wedge is of proper size, when the surfaces are brought into contact the limb is at the limit of normal abduction, or at an angle of 45° with the body. The wound is then closed and a short plaster-of-Paris spica bandage is applied to fix it in this attitude until repair is complete, the usual time being about three months. When the limb is restored to the line of the body the neck of the femur is elevated to its normal angle. Function is thereby restored, and the patient is cured. (Fig. 623.)

Measurement will show that this procedure makes the limb somewhat longer than before the operation, the actual shortening being rarely more than half an inch. Massage, exercises, and supervision are of value if they can be provided, although, according to the writer's experience, they are not essential to success. (Figs. 624 and 625.)

In older subjects there is often marked posterior distortion of the neck, shown by extreme outward rotation of the limb. In cases of this class simple linear osteotomy is preferable. Muscular contraction having been overcome in the manner already described, the so-called subcutaneous osteotome is pushed directly through the tissues at a point about three inches below the apex of the trochanter. The cortex of the outer surface is divided and the bone is sufficiently weakened to permit fracture when the limb is forcibly abducted. When the bone is broken, the limb is, under traction, rotated inward to bring the foot into normal position, and, in the attitude of normal abduction, it is fixed in a long spica bandage that includes the foot.

In cases of the adolescent type in which it may be inferred that the neck of the bone is somewhat softened, the period of protection must be much longer than in the preceding class. Thus it is of advantage for the patient to use a convalescent hip splint for several months, massage and proper exercises being employed to improve the circulation and to strengthen the muscles.

There are certain cases in adolescence in which the deformity, often bilateral, has advanced very rapidly. In cases of this type it may be possible actually to straighten the neck by forcible abduction of the limb without osteotomy, in the manner already described.

The treatment of traumatic partial epiphyseal separation is properly included under that of fracture of the neck of the femur. (See the article on Fractures in Vol. III.) As has been stated, this injury is favored by coxa vara, especially of the epiphyseal type, and these secondary forms of epiphyseal separation can hardly be distinguished from those induced by primary injury. In both instances the relation of the joint surfaces is so changed that persistent disability must follow unless the head of the femur is replaced in its proper position. In favorable cases, therefore, this should be attempted. An incision just to the outer side of the anterior superior spine, about four inches in length, is made directly downward. This exposes the interval between the tensor vaginæ femoris on the upper and the gluteus medius muscle on the lower side. When these are widely separated the anterior wall of the capsule is exposed. This is opened in the line of the neck, and when the limb is rotated outward the deformity is exposed. There is usually displacement of the head downward and backward. A thin chisel is driven through the neck so that the head is completely separated. It is then, by the leverage of the chisel, pushed upward and inward while the limb is forcibly abducted and rotated inward, the parts being thus replaced in proper position. If necessary, a thin section of bone may be removed from the inner extremity of the neck to facilitate this replacement. The wound is then closed and a

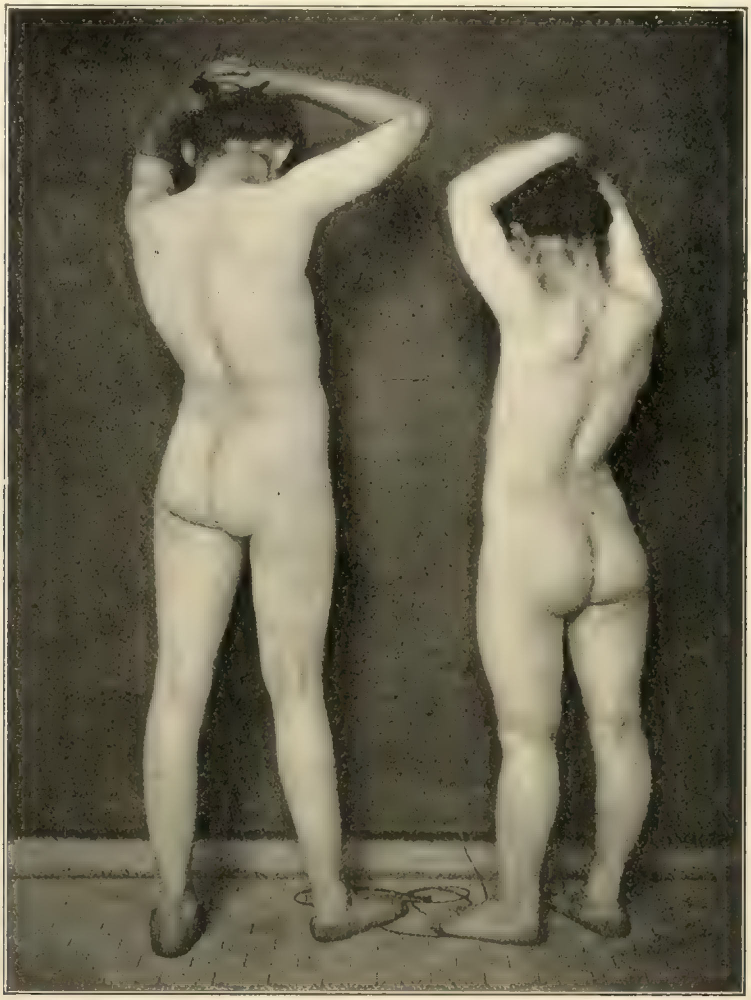


Fig. 624.—Coxa Vara in Sisters. Right in the elder; left in the younger; both of the rhachitic type. (See Fig. 623.) (Original.)

plaster-of-Paris spica bandage is applied to fix the parts until repair is complete. The after-treatment is the same as has been described.

It may be noted in the review of treatment that stress has been laid upon prevention of deformity and upon positive correction. In cases that are not treated, the distortion tends to increase for a time until the discomfort and disability enforce rest, and until further depression is resisted by the compressed bone on the under surface of the neck. When, after an indefinite time, this limit has been reached, pain ceases, muscular spasm disappears, and the range of motion increases, but the deformity persists. The patient limps, or walks awkwardly, and is, to this extent, placed at a disadvantage. The importance of treatment, therefore, to assure an actual cure, as contrasted with this natural process, is apparent.

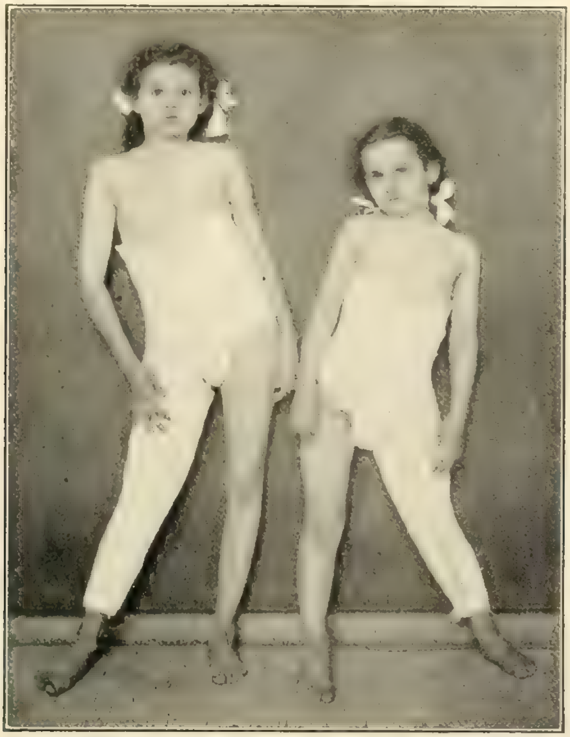


Fig. 625.—Illustrating the Operative Treatment of Coxa Vara. The same patients are shown in Fig. 624.

II. COXA VALGA.

Coxa valga signifies an abnormal elevation of the neck of the femur. The deformity is uncommon and of but slight importance. It is sometimes observed in limbs that have never supported weight and it is a possible result of injury in which the epiphyseal extremity of the femur has been forced upawrd.

In very rare instances, as a congenital deformity, coxa valga may cause symptoms when the child begins to walk, the most noticeable peculiarity being slight persistent abduction and outward rotation of the limb, and the opposed movements being correspondingly restricted. If this restriction cannot be overcome by manipulation and training, the deformity may be remedied by osteotomy.

III. DISTORTIONS OF THE BONES OF THE LOWER EXTREMITY.

There are three common distortions of the lower extremities: Bow-leg (genu varum), knock-knee (genu valgum), and anterior bowing of the leg (anterior bow-leg). But although the outward expression of the deformity classifies it usually as of one or another of these types, not infrequently all three distortions may be present in one limb.

For example, in cases of extreme rhachitic deformity the femur is usually bent forward and outward above, and inward at the knee, while the tibia inclines outward and forward and is finally turned abruptly inward above the ankle. Such "corkscrew" distortions can hardly be classified as either bow-leg or knock-knee.

Etiology.—As is well known, the principal factor in the etiology of deformities of the bones is rhachitis. (Fig. 626.)

In the clinics of New York, the Italian and the colored children furnish a disproportionate percentage of the most extreme cases, but in the milder forms the affection is far from uncommon even among the favored classes. Rhachitis lessens the resistance of the bones and correspondingly decreases the strength of the muscles and other tissues. The erect attitude subjects the weak bones to the strain of weight and motion; thus the deformities increase most rapidly when the child begins to walk; but in many instances the manner of sitting, of creeping, and the like, has already determined the deformity.

Another example of external influence is seen in bow-leg of one side combined with knock-knee of its fellow, a deformity not at all uncommon among Italian children, and induced, it would appear, by carrying the child, often enveloped in swathing clothes, habitually on one arm, the limbs being pressed against the mother's chest.

Bow-legs are more common than knock-knees. In a period of ten years at the Hospital for Ruptured and Crippled, 3,452 cases of bow-legs were treated, 2,030 of which were in males. In the same period the number of knock-knees was 1,989, 1,024 being in male subjects. Anterior curvatures of the tibiæ rarely exist as a single deformity and are more often combined with knock-knees than with bow-legs. All rhachitic deformities are, as a rule, bilateral, and they are somewhat more common in males than in females.

Aside from the direct deforming influences that have been mentioned, it would appear, according to Wolff's law, that the deformity must be the result of adaptation to the physical condition of the patient. A very weak child on attempting to stand seizes some support, the knees are pressed together, the attitude being one of semi-flexion so that the weight tends to bend the tibiæ forward. And, as has been stated, it is a common observation that knock-knees and anterior curvatures are more often combined than other deformities; also, that well-marked knock-knee is usually a rhachitic deformity, while a corresponding degree of bow-leg may exist in otherwise normal children.

Bow-leg of slight degree may be congenital; it is often present in combination with congenital club-foot. It is not uncommon in children who are vigorous and begin to stand at a very early age. Knock-knee also in slight degree is not uncommon, particularly in female children. It is often associated with flat feet in children who, though weak, are not rhachitic, and in general the popular belief that this deformity is characteristic of weakness is well founded.

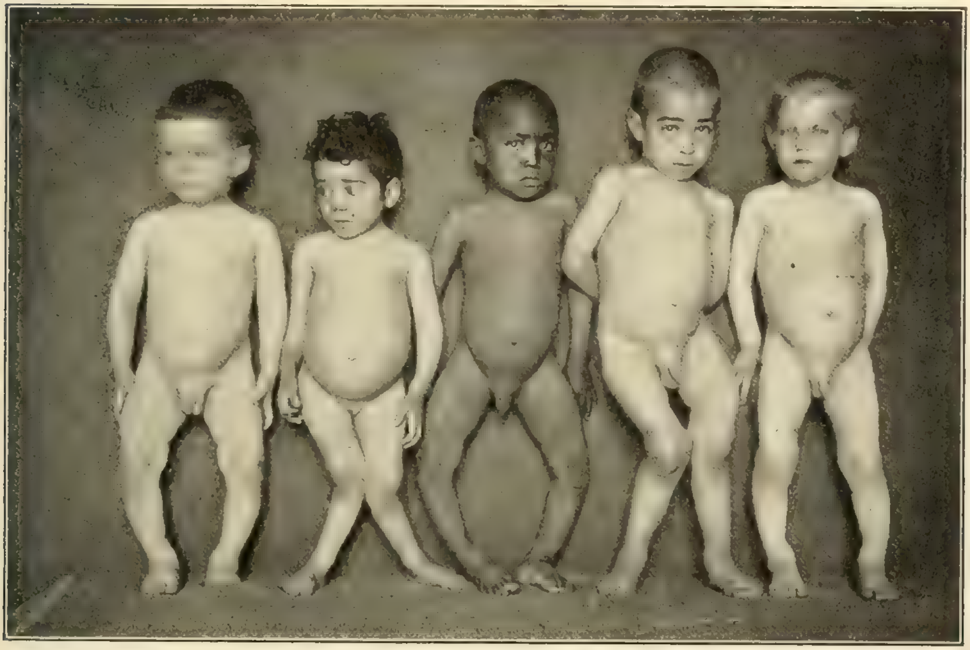


FIG. 626.—Various Forms of Rhachitic Deformities of the Lower Extremities. No. 1, The ordinary type of genu varum, No. 5, true bow-legs not involving the knees; No. 3, extreme genu varum; No. 2, Extreme genu valgum, showing the general distortion of the bones; No. 4, unilateral genu valgum combined with general rhachitic deformities. (Original.)

Thus far, mention has been made of inherited or acquired weakness or other predisposition that becomes operative in early life. There is also a second period in which deformity, or at least increase in curvature, may appear. This is adolescence, when rapid growth makes the bones less stable and when the strain of laborious occupation may be an exciting cause. Occupation, even in ordinary individuals, has a very decided influence in inducing deformity. Thus, in Vienna, "baker's knee" is the popular term for genu valgum, and those who ride constantly have, in many instances, outward bowing of the legs.

The influence of injury, such as fracture or rupture of ligaments at the knee, or of disease of the joints, in inducing deformity is apparent, but cases of this character do not require consideration in this article.

The Outgrowth of Deformity.—In concluding the consideration of etiology, the process of natural cure, or outgrowth of deformity, may be mentioned, for, as is well known, there is a strong belief, shared by the profession and laity alike, that these deformities are usually outgrown and that treatment is therefore unnecessary. If one looks upon deformity as a functional adaptation to weakness, it is evident that a natural gain in strength should lead to the adoption of attitudes that would tend to correct it. So also it is apparent that the lengthening of the limb in growth will lessen proportionately the distortion. And, again, in the cases in which the limbs are twisted in various directions, the outward expression might well be transformed from bow-leg to knock-knee, or *vice versa.* But in general it may be stated that deformities of this character, although they become less noticeable, do not usually disappear entirely. This is evidenced by the number of distortions of this class that may be seen in adult males, which, although occasionally developing in mature years, are in the great majority of cases instances of deformity that has persisted since childhood.

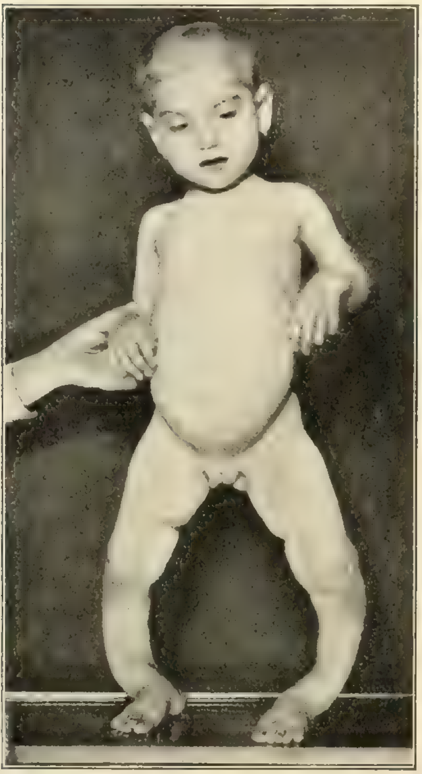


FIG. 627.—Marked Bowing of the Bones Below the Knees without Involvement of the Femora.

Having considered these deformities of common origin in general, one may take up the individual distortions in order of frequence.

Bow-Leg (Genu Varum).—There is a certain distinction between bow-leg, strictly speaking, and genu varum. The first implies bowing of the leg below the knee, and the second bowing at the knee. If, however, the bowing is in the lower third of the leg, the effect is to abduct the femur so that the knee is bent outward. And in those cases in which the deformity is most marked at the knee, the tibia is practically always deformed. There is this distinction: in simple bow-leg the deformity may be confined to the tibia and fibula, while in genu varum the femur, the bones of the leg, and in some degree the ligaments at the knee are involved.

The deformity is so well known that further description is unnecessary. The relation of the bones at the knee may be unchanged, but, as a rule, the femur is rotated somewhat outward and the tibia inward. Thus intoeing is not unusual. There are other general adaptive changes in the shape of the bones and in the articulations, due to the altered conditions of weight and strain, but these hardly require extended comment.

Treatment.—The prevention of deformity by the treatment of rhachitis and by the prevention of postures that predispose to it, is, of course, of great importance. At an early age, manual correction of the deformity—that is, straightening the distorted bones by gentle force many times daily—may be effective. If the child has already begun to walk, braces are often of service.

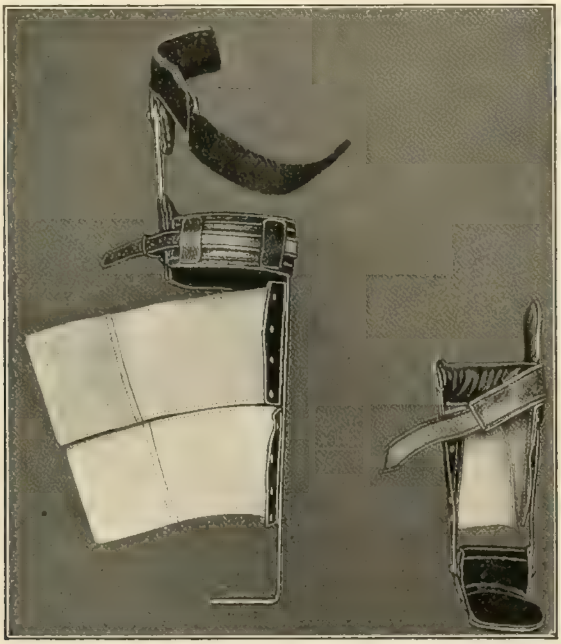


Fig. 628.—The Short ("Knight") and the Long ("Napier") Bow-leg Braces.

The principle of the brace for bow-leg is essentially simple. It is a splint applied on the concave side, to which the limb is fastened with a certain pressure. If the deformity is below the knee, a short brace is used. For example, a light bar of steel is fitted to the inner side of the sole of the shoe, with a joint at the ankle. Its upper extremity is provided with a pad for pressure on the internal condyle of the femur, and a leather lacing or strap is passed about the leg and tightened to the point of comfort. If the deformity is most marked at the knee, the brace must extend to the neighborhood of the pubes, and in order to assure its position a metal band is often passed in front of the thigh to the outside and is joined to a pelvic band. Pressure is then exerted, particularly at the knee. (Fig. 628.) The object of the brace is support rather than active correction, for if the progress of deformity is checked the limb will gradually grow straighter. To hasten correction, methodical manual correction and massage should be employed.

Operative Treatment.—If by manual pressure the bones are found to be yielding, cure by braces, if properly used, may be predicted, the time required being from six months to a year. In walking children of three or more years of age, if the deformity is well marked and resistant, operative correction is advisable. The operation is practically free from danger, and the result is satisfactory. If, for example, the deformity is confined to the legs and is most marked just above the ankle, complete and immediate correction will assure a cure in a few weeks. But if it is more general and if, as when caused by rhachitis, it is accompanied by laxity of ligaments at the knee, after-treatment by braces is often required, even though the deformity has been overcome.

One of the most satisfactory procedures in the milder type of cases in young subjects is manual correction. The limb is seized with the hands and forcibly overcorrected, the fracture being of the green-stick variety. For instrumental osteoclasis the best appliance is the Grattan instrument, the bones being bent and partly broken at the point of greatest deformity. This is usually sufficient; but, if the distortion is severe, fracture both above and below the knee may be necessary. This may be performed at one sitting, or the second operation may be deferred until the effect of the first is noted.

Osteotomy is equally efficacious by means of the so-called subcutaneous osteotome. This instrument, about the size of a lead pencil, flattened to a cutting edge, is forced through the skin at the concavity of the curve of the tibia. It is then turned to a right angle with the axis of the limb and driven through the cortex of the bone, then withdrawn slightly and forced into one and the other side until the bone is sufficiently weakened to allow fracture by the hands. The fibula being bent or broken to conform to the correction, the minute wound is closed with a single suture, and the plaster bandage is applied, the deformity having been considerably overcorrected.

In many instances the operation being performed at the point of greatest deformity, sufficient correction may be attained to compensate for the slighter bending of the other bone. If not, it may be well to defer the second osteotomy until the result of the first operation has been tested. For it will be borne in mind that if by the operation the static conditions are changed the natural transformation will bring about ultimate symmetry. Whatever operation is performed, the deformity must be overcorrected. The bow-leg must be transformed to knock-knee, and *vice versa*, and the part must be fixed in the new position by a plaster bandage or other support for about eight weeks. If one is in doubt on the question of under- or over-correction of deformity, the bandage may be removed in three weeks, when, the bone being flexible, the position may be rectified and a new support applied. When this is finally removed, massage, exercises, and caution as to the degree of strain imposed are of course necessary. If there is the slightest sign of further yielding, braces must be employed. The general condition of the patient must, of course, receive attention in cases in which weakness or active rhachitis is present.

Knock-Knee (Genu Valgum).—In the erect posture, with the limbs in contact, the femora, separated above by the pelvis, incline somewhat inward to the knees. Thus, the limbs are not absolutely straight, but form at the knees angles opening outward of about 172°. This angle is somewhat more acute in females, in whom what may be called normal knock-knee is often present.

In cases of noticeable deformity the knees come into contact, so that the feet cannot be placed side by side—hence the popular name.

In the ordinary form of genu valgum the deformity is most marked in the neighborhood of the knee, the lower extremity of the femur being so bent that the internal condyle is on a lower plane than the external, so also the internal bearing surface of the tibia is somewhat higher than the external. In certain instances the deformity inducing the knock-knee may be almost entirely confined to the lower extremity of the femur, in others to the upper third of the tibia. Or, again, the deformity may be almost entirely caused by a sharp outward bending of the tibia at the middle, the bones at the knee joints being fairly normal in contour. In other instances the distortion of the bones may be general, as in the so-called corkscrew deformity that has been mentioned. In addition to the direct deformity of the limbs there are secondary changes in the contour of the bones. For example, in advanced cases the tibia is flattened from before backward and its crest is apparently transferred to the inner

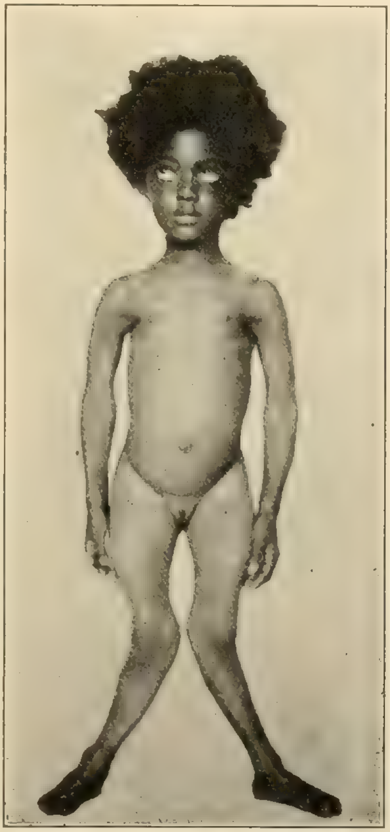


FIG. 629.—Genu Valgum, illustrating the Adaptive Change in Contour of the Tibiæ. (Original.)

border. (Fig. 629.) Accompanying these external changes there is a corresponding transformation of the internal structure.

Genu valgum, as compared to genu varum, is a much more serious affection, and, aside from the distortion itself, is accompanied by changes in the relation between the component bones at the knee. For example, the femur is rotated inward, and the tibia is rotated outward, the patella being displaced somewhat to the outer side. When the limb is flexed the deformity disappears, as explained by the mechanism of the knee, the tibia sliding in flexion behind the projecting inner condyle. Thus complete extension exaggerates the deformity, and the patient is inclined to walk with the knees slightly flexed. This in fact is the habitual attitude in the ordinary type of rhachitic knock-knee, which is therefore often accompanied by flexion contraction at the hips and knees and by retraction of the tissues on the outer side of the knees.

Etiology.—As has been stated, knock-knee is symptomatic of weakness, and the relation of the bones at the knee is an exaggeration of that characteristic of the so-called attitude of rest. Knock-knee, then, is a deformity that may be directly induced by the habitual assumption of the predisposing attitude, as in the cases often seen in adolescence, in which the deformity is in great degree dependent upon the changed relation of the bones at the knee and by laxity of the ligaments. In young children knock-knee is often accompanied by so-called flat feet, and the intoeing attitude—nature's method of resisting the progress of the deformity—is often the symptom that attracts attention. In well-marked knock-knee of long duration, this compensatory resistance is often shown in well-marked varus deformity of the feet.

Symptoms.—The symptoms of knock-knee are, practically speaking, the deformity itself. There is also, even in mild cases, a peculiar awkwardness in the gait due to the necessity of avoiding interference at the knees, and in adolescent subjects there are usually sensations of weakness and discomfort after long standing, referred to the inner aspect of the knee.

The pathology is comprised in the deformity and the changes incidental to it.

Treatment.—If the deformity is discovered in early childhood, the limbs should be straightened by methodical manipulation applied many times during the day. If it is accompanied by flat feet the inner border of the shoe should be made one-fourth of an inch thicker than the outer border in order to lessen the strain upon the knee. If the child is walking about and if the deformity is increasing, braces are indicated. If these are to be effective in actual correction there must be no joint at the knee, because the natural attitude of compensation for the deformity is flexion, which should be prevented.

An effective brace is that of Thomas, which consists of a straight bar of steel reaching from the trochanter to the heel of the shoe. At the upper third of the thigh part, and at a point opposite the middle of the calf, are thin steel bands long enough to encircle about three-quarters of the limb. These are connected by a straight bar passing behind the centre of the knee. The brace being adjusted, the knee is drawn outward toward the outer bar and backward toward the posterior bar, by bandages at a tension not sufficient to cause discomfort. The effectiveness of the brace is still further increased by the addition of a divided pelvic band joined to its fellow by straps behind and in front by which the rotation of the limb may be regulated. The braces are worn when the child is on its feet, and their use should be combined with massage and manual correction at morning and night. Under favorable conditions the deformity may be corrected in about six months. (Fig. 631.)

Operative Treatment.—In the stage of active rhachitis the deformity may be corrected easily by the application of plaster bandages in an improved position; or at one sitting, if anaesthesia be employed; but, as a rule, in this class subsequent support is necessary to prevent recurrence of the distortion. In the ordinary type the deformity is most marked at the lower third of the femur, and if the bone be fractured at this point the correction of the obliquity of the condyles will usually overcome the knock-knee. If, however, the distortion is more general it may be necessary to straighten both the femur and the tibia. In other instances the deformity is practically confined to the tibia, in which case the correction may be confined to this bone. Whenever the distortion is marked, an *x*-ray picture is of value as indicating the proper site for operative correction.

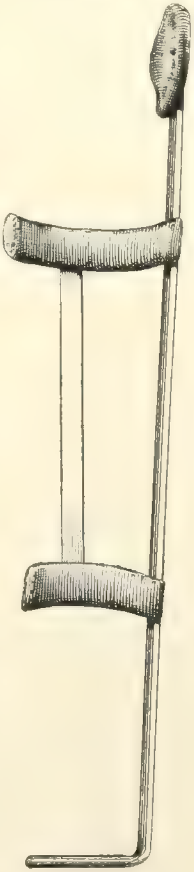


FIG. 630.—The Thomas Knock-knee Brace.

The typical operation for the ordinary type of knock-knee is supracondylar fracture, subcutaneous osteotomy being perhaps the operation of choice. The limb having been prepared, the patient is turned upon the side and, the inner aspect of the knee being supported on a sand bag, the lower extremity of the femur is grasped by the fingers and the subcutaneous osteotome is thrust directly down upon the outer aspect of the bone at a point about one inch and a half above the prominence of the external condyle, that is, about three-quarters of an inch above the epiphyseal cartilage. The blade is then turned to a right angle and is driven into the cortex on one side and the other until it is sufficiently weakened to allow fracture with the hands, a wedge-shaped opening being left on the outer side and the bone being bent without separation of the two fragments. The wound is closed with a catgut suture, and a spica plaster bandage is applied in the attitude of overcorrection (moderate genu varum). Both limbs are operated upon at one sitting. If the deformity is severe, the correction should be made both above and below the knee. In this case, if both limbs are to be operated upon, it may be well to postpone the second operation for several weeks. If, however, osteoclasis is employed, in which the fracture is less complete, the correction may be made above and below at the same time. For osteoclasis the Grattan osteoclast is to be preferred, the attempt being made by adjusting the instrument to fracture the femur or the tibia or both at the points of greatest deformity.

Some surgeons—for example, Lorenz—who practise osteoclasis attempt to separate the epiphysis from the diaphysis in the correction, on the ground that the deformity is thus more perfectly corrected. But the distance of three-quarters of an inch, the point of election for osteotomy, is equally efficacious without the possible danger of injury to the growing bone. The plaster bandage is retained for a number of weeks, four to eight, and then massage and exercises should be employed, resumption of function being gradual. In rhachitic cases support by braces may be necessary for a time.

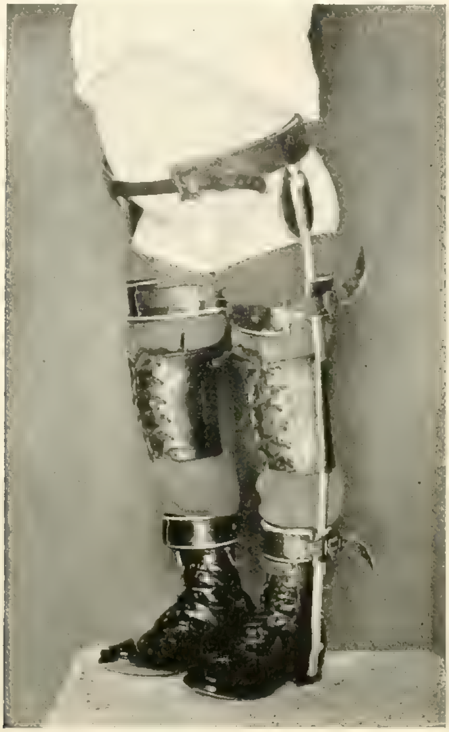


Fig. 631.—The Modified Thomas Brace with Pelvic Band, Showing Overcorrection of Deformity.

Genu varum of one limb combined with genu valgum of the other causes a very peculiar attitude, for the base of support is displaced, as it were, to one side. In such cases operative treatment is indicated rather than the mechanical.

Anterior Curvature of the Legs.—Anterior bow-leg usually complicates general distortion of the limbs, and it is more often combined with knock-knee than with bow-leg. In this deformity the tibia is flattened from side to side, it curves forward, and its anterior border is often prominent. The deformity is practically always bilateral, and as the weight of the body is thrown forward it causes a very awkward shuffling gait, the heels being prominent and the foot flat.

Anterior curvature of the tibia is usually caused by rhachitis. It is, however, a characteristic deformity of chronic ostitis and thus a not uncommon manifestation of hereditary syphilis. In such cases the bone is elongated and hypertrophied in addition to the distortion. Other causes hardly need consideration. The treatment of anterior bow-leg is like that of other rhachitic distortions. It may be corrected in the stage of formation by manipulation. Its progress may be checked by the use of a brace consisting of two upright bars placed on either side of the leg and carrying a leather band to provide pressure on the most prominent part of the curvature.

If the deformity is advanced, the bone is not amenable to correction by braces, and operative treatment is indicated.

Osteotomy or osteoclasis may be performed, the aim being to hold the bone in line and to open a wedge on the posterior surface. This necessitates vigorous stretching of the soft parts, and in confirmed cases division of the tendo Achillis is necessary. In many instances more or less overlapping of the anterior border will follow correction, especially if, as is often the case, lateral distortion must be corrected as well. This may be avoided by a cuneiform osteotomy, but, although the immediate effect is more symmetrical, the ultimate result is no better than when the bones are simply broken, for it must be borne in mind that complete correction of deformity can be effected only by the natural process of growth.

IV. PARALYTIC DEFORMITIES OF THE LOWER EXTREMITIES.

In the etiology of the disabilities and deformities of the extremities following paralysis, anterior poliomyelitis is by far the most important factor.

This, as is well known, is an affection, practically speaking, limited to infancy and early childhood. Thus, to the direct effects of the paralysis are added the distortions favored by the immaturity of the individuals and the loss of growth that follows destruction of the nerve centres in the spinal cord, and the effects due to functional disuse.

Deformity after anterior poliomyelitis has several more or less direct causes, notably, the force of gravity, unbalanced muscular action, and functional use of the disabled member.

Loss of growth corresponds primarily with the degree of paralysis, and secondarily with the loss of function. In some instances one may note a widespread paralysis and yet the nutrition of the limb, and particularly the circulation, are fairly sustained, while in another instance the paralysis may be limited, yet the limb is ill nourished and the growth markedly checked. The influence of functional use is even more direct. If, by the aid of support, the limb has been enabled to perform a part of its function, its growth and nutrition are greatly improved as contrasted with one which, because of deformity, is functionally useless.

The most important function of the lower extremity is to support weight, and for this even a completely paralyzed limb is capable when properly braced, so that it shall be straight and that the foot shall be held at a right angle to it.

The essential part of the later treatment of anterior poliomyelitis is the prevention of deformity by the proper support of the more or less disabled part during the growing period. When full growth is attained patients are often able by the power of accommodation to the weakness to discard apparatus in whole or in part.

At present, however, because of the lack of preventive treatment, the correction of deformity must usually precede the application of apparatus.

Each muscle of the limb has its function more or less important, the knowledge of which enables one to predict the disability and deformity that will result from its loss.

Such results are more directly appreciable in the various distortions of the foot, which are described under Talipes.

Loss of the quadriceps extensor muscle causes an awkward gait, the patient swinging the limb forward and, as it were, locking the knee-joint at each step. If, as is usual, persistent flexion follows, the gait is very uncertain, the patient often placing the hand upon the thigh to prevent the giving way when weight is borne. Paralysis of the muscles that control the hip affect both the movements of the body and those of the limb. The posterior muscles raise the body when bent forward, while the ilio-psoas is the most important of the flexors. If paralysis of the hip muscles is complete the gait is, of course, very insecure and awkward. In those cases in which the paralysis of the limb is extensive, the brace employed should be simple and strong, consisting essentially of two uprights of steel of sufficient strength, passing on either side of the limb and joined by a thigh- and calf-band of thin sheet steel, while the foot is supported by a sole-plate fixed at a right angle. The outer bar is carried upward to a point above the trochanter, where it is jointed to a pelvic band of light steel. This is then suitably padded and is adjusted with straps about the pelvis, thigh, and calf. It has but one joint, that at the hip, and, thus being subjected to but little strain, it may be made of light material. If the hip muscles are active the pelvic band is not necessary. In the treatment of older subjects a joint and lock at the knee that will allow the patient to flex the limb in the sitting posture are of advantage.

As has been stated, deformity is an almost inevitable sequel of paralysis, and in nearly all cases its correction is necessary before apparatus can be applied. If the paralysis is extensive, the usual distortion is flexion both at the hip and knee and also at the ankle (plantar flexion). This is partly due to posture and in part it is explained by the fact that the tensor vaginæ femoris often retains its power when that of the other muscles is lost. So also the posterior muscles of the limb are less often completely paralyzed than those on the anterior aspect.

CORRECTION.—In certain instances the deformities can be overcome by methodical stretching and subcutaneous tenotomy under anaesthesia, but if the contraction is of long standing it is well to divide the contracted parts by open incision. An incision is made directly downward in the line of the limb from the anterior superior spine, and the shortened muscles and fascia lata attached in this neighborhood are divided and the wound is closed. So, also, at the knee, if there is much resistance, it is better to cut the resistant tissues than to use great force, which might induce subluxation of the tibia or crush the atrophied bones. The same method is followed at the foot and a long spica plaster bandage is applied. If this is not too heavy, the patient may soon walk about on it and become accustomed to the improved position. In a month or more the brace may be applied. Massage and exercises are important in the after-treatment.

The operations of arthrodesis and muscle transplantation are described in connection with deformities of the foot. Elsewhere they are of comparatively little importance. Arthrodesis at the knee-joint is not often employed because the majority of the patients prefer to wear a brace rather than to be unable to flex the knee when sitting. Again, the operation, performed as it usually is in childhood, does not assure the patient against deformity, as does an excision in adult life. In fact, in most instances support is necessary to assure the patient against flexion at the knee or fracture of the atrophied bones.

The operation, in its details, is like excision, except that only a thin section is removed from the adjoining bones. They are then firmly sutured to one another and a plaster bandage is applied. The patient is encouraged to use the limb in walking as soon as the sensitiveness has subsided.

Arthrodesis at the hip rarely assures bony ankylosis, but the security of the part is increased. The joint is opened by the antero-lateral incision employed in the treatment of congenital dislocation of the hip. The head of the bone is exposed by outward rotation and extension, and the cartilage is removed. A sharp spoon is then introduced into the acetabulum, which is in turn bared. The parts are then replaced and the limb is fixed in moderate abduction and extension by means of a plaster spica bandage. The usual result is fibrous ankylosis, with a tendency to flexion and adduction deformity. Thus the part must be supported by a brace or other means for a long time. The operations, particularly at the hip, are useful in selected cases.

If the quadriceps extensor muscle is paralyzed and the sartorius retains its power, the latter may be utilized to restore, in some degree at least, the power of extension. A long incision is made on the lower third of the inner aspect of the thigh, somewhat to the inner side of the patella. The sartorius is recognized as the only muscle whose fibres run downward and inward. It is divided just over the joint, freed from its attachments, and at a certain tension is firmly sewed with silk to the tendinous attachment of the quadriceps extensor. The wound is then closed and the limb is supported in the extended position for several months. A certain power of extension is usually regained.

Tendon Transplantation.—As has been mentioned, one of the causes of deformity after paralysis is unbalanced muscular action. A muscular group which has lost its antagonist, stimulated by the necessity of carrying on function, distorts the part on which its force is exerted. In such cases removal of the deforming agency even may be of advantage, and if at the same time the power is transferred to a point at which it will counteract the tendency toward distortion, the patient may be greatly benefited.

As a rule, tendon transplantation should be considered as palliative rather than curative, for as each muscle has its special function its loss can never be perfectly replaced by any rearrangement of the remaining power.

The first operation of this character was performed by Nicoladoni in 1882, who transplanted the two peronei muscles to the tendo Achillis for the relief of paralytic calcaneus. Since then many modifications have been introduced. Originally, the tendon of the active muscle was usually apposed to that of the paralyzed one, or, if divided, it was sewed to it. At the present time the suggestion of Lange to remove the tendon of the transplanted muscle from its former position and to attach it directly to the periosteum or to the bone itself at the point of greatest mechanical advantage, is more often followed. If the tendon is too short for this purpose, it may be lengthened to the desired degree with a strong silk cord, which in time is replaced by fibrous tissue.

The operation of tendon transplantation should not be performed until the exact degree of irremediable paralysis is ascertained. Thus, preferably, it should be deferred for several years after the onset of the paralysis. Nor should it be performed until after all deformity has been corrected, so that weakened muscles may have had an opportunity for development. The most favorable class, therefore, is the adolescent, in which the patients have received efficient protective treatment and in which the paralysis is limited in extent. The first essential is a knowledge of the function of the muscles that support the foot, for it is here that the great majority of operations are performed.

The following table, modified slightly from that of Codivilla, illustrates the function of the muscles and their relative importance in simple and combined movements:

	Dorsal flexion.	Plantar flexion.	Adduction.	Abduction.	Pronation.	Supination.
Tibialis anticus	1	. .	. .	. .	. .	1
Extensor proprius hallucis	3	. .	. .	. .	. .	6
" longus digitorum	2	. .	. .	3	3	. .
Peroneus brevis	. .	6	. .	2	2	. .
" longus	. .	3	. .	1	1	. .
Gastrocnemius and soleus	. .	1	2	. .	. .	2
Tibialis posticus	. .	4	1	. .	. .	3
Flexor longus hallucis	. .	2	3	. .	. .	4
" " digitorum	. .	5	4	.	. .	5

The strength of a muscle may be fairly estimated by its weight, which, according to Fick, is indicated by the following table:

	Grams.		Grams.
Tibialis anticus	49.2	Tibialis posticus	39.6
Extensor longus hallucis	12.3	Flexor longus hallucis	33.2
Extensor longus digitorum	18.2	Flexor longus digitorum	12.3
Peroneus tertius	3.5	Peroneus longus	24.0
Gastrocnemius and soleus	277.0	Peroneus brevis	16.5

It will be noted that the weight of the tibialis anticus is greater than that of all the others on the front of the foot, and that the weight of the calf muscle is considerably greater than that of all the others combined.

Certain suggestions may be made as to the operation of tendon transplantation, the details of which are described elsewhere. (Vol. II.)

First, that it is at best a palliation rather than a cure.

Second, that a weak muscle cannot take on the function of a stronger one in addition to its own; therefore it should be entirely separated from its former attachment and placed at the point at which it may work at best advantage. On the other hand, a portion of a strong muscle may be used to replace a weaker one.

Third, muscles of similar function work at better advantage when transferred than those whose function is opposed. An extensor on the back of the leg, for example, can hardly serve efficiently as a dorsal flexor.

Fourth, whenever this is possible tendon transplantation for the relief of deformity should be supplemented by other procedures—such, for example, as are described under Talipes.

V. CEREBRAL PARALYSIS AND ITS DEFORMITIES

Cerebral paralysis, as compared with anterior poliomyelitis, is, from the orthopedic standpoint, of slight importance. The lesion being of the brain, the distribution of the paralysis varies. It may be diplegic, paraplegic, or hemiplegic. The diplegic and paraplegic distributions usually indicate congenital defect or disease, and are almost invariably accompanied by mental impairment, often to an extreme degree.

Hemiplegia is more often the result of disease after birth, and the cerebral impairment is correspondingly less.

As far as deformity is concerned, there is usually slight flexion at the hip, with a tendency toward adduction and equino-varus deformity of the foot. The patient, provided the equilibrium is sufficiently stable to permit locomotion, walks about with an awkward, shuffling gait. In this affection the reflexes are exaggerated and the disability is due to loss of control rather than to actual paralysis. In the early years of life the deformities may be overcome easily by manipulation, but later they become fixed by retraction of the muscles. In early life, therefore, systematic manipulation and massage, combined with training, may lessen the disability and, for a time, leg braces, which are attached to a pelvic band and which hold the limbs in a symmetrical position, may be of service. In many instances, particularly in the older cases, multiple tenotomies of the contracted muscles serve a useful purpose in overcoming deformity and lessening, by elongating the tendons, the exaggerated muscular response to stimulation.

Thus, in certain instances the adductors and flexors at the hip and the posterior tendons at the knee and ankle may be elongated with advantage. Tendon transplantation may be employed also for the same purpose. In some instances the hamstrings have been transferred to the anterior aspect of the thigh and inserted by means of silk tendons into the patella. The ultimate improvement in such cases is due probably more to the direct removal of the distorting force than to the positive gain in the opposing group.

An operation of more direct value is the splitting of the tendon of the tibialis anticus and the attaching of the outer half to the outer border of the foot, as described in the section on Talipes.

It must be borne in mind that there is no actual paralysis of the muscles in cerebral palsy, but rather a paresis and loss of control. On this account one must not fix the parts for too long a time in the overcorrected position, for fear of replacing one deformity with another. This applies particularly to the foot in which calcaneus may take the place of equinus after tenotomy of the tendo Achillis if the overcorrection is extreme.

VI. VARIOUS DISABILITIES OF THE FOOT.

The Weak Foot; Flat-Foot; Splay-Foot.—By far the most important of all the disabilities of the foot is the so-called flat-foot, a popular but misleading term; misleading because it calls attention to an effect rather than to a cause. For in a very large proportion of the cases the lowering of the arch is simply the result of habitual posture, the normal elevation being restored when the proper attitude is assumed. (Figs. 632, 633.)

The foot, when properly used, is under direct control of the muscles, and the attitudes assumed are those which are adapted to the work that is required of it. Thus the attitudes of activity are opposed to those of rest, and it is this alternation of postures that protects the foot from overstrain.

In shoe-wearing people, however, the foot is often habitually used as if its only function were to support weight. To illustrate: when the foot is turned inward on the leg (adducted), it will be noted that its inner border is concave, the arch is increased in depth, and the sole is inverted. When it is turned outward (abducted), the sole is everted and the internal contour is convex. In the normal attitude of activity—for example, in walking—the strain represented by a line drawn through the centre of the leg should pass over the second toe, practically the centre of the foot. Thus, falling momentarily on the heel, the strain is transmitted along the outer border of the foot to the front. As the body is lifted by the calf muscle the weight is directed outward because the line of the metatarso-phalangeal joints or fulcrum is oblique—the outer the short, the inner the long, side. (Fig. 634, *a*.) This presupposes the proper attitude in

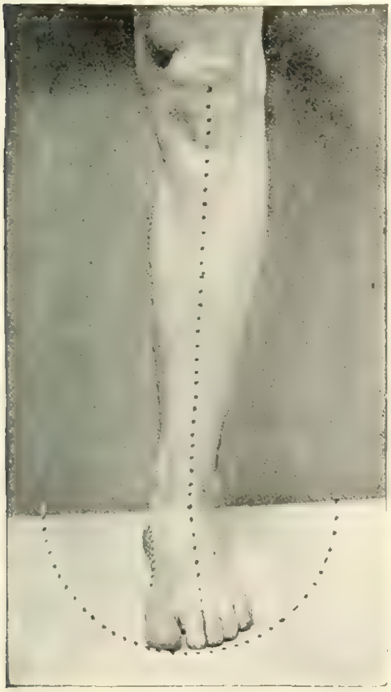


FIG. 632.

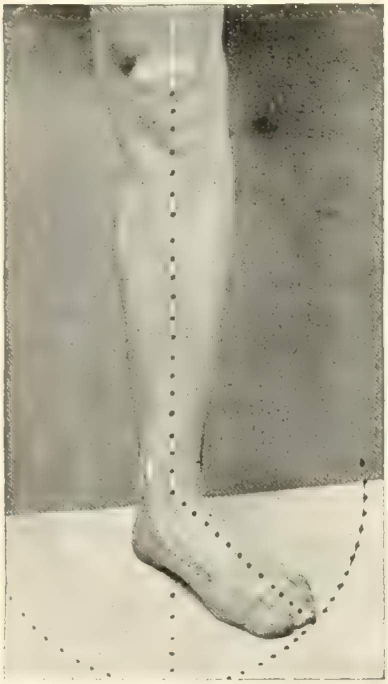


FIG. 633.

FIG. 632.—Illustrates Voluntary Protection of the Foot from Overstrain. (Compare with Fig. 633.)

FIG. 633.—A Normal Foot Placed in the Attitude of Abduction, Illustrating the Simulation of Weak or Flat-foot. (See Fig. 632.)

walking, in which there is but very slight turning outward of the toes, and in which there is a "spring" in the gait.

In the passive attitude, on the other hand, the feet are turned outward to assure a wide base of support. There is, in great degree, muscular relaxation. The feet are in what is known as the attitude of rest, in which the weight is supported principally by the ligaments. If the weight is supported on one limb, as when the individual stands at ease, the foot is abducted or everted in its relation to the leg, the weight is thrown on its inner side, and the line of strain falls inside the great toe. This attitude, proper when the foot is at rest, is manifestly abnormal when active work is required of it, and yet the habitual assumption of an approximation to this posture is very common in otherwise normal individuals. (Fig. 634, *b*.) Indeed, exaggerated outward rotation of the limbs is often enforced on children by parents and teachers, because it is thought to be a graceful attitude rather than one which necessitates an awkward gait and which predisposes to disability. Outward rotation of the limb, a movement taking place at the hip joint, must not be confounded with abduction of the foot, in which the movement is made at the joints in front of and below the astragalus. Outward rotation predisposes to abduction, and persistent abduction may be readily exaggerated to deformity.

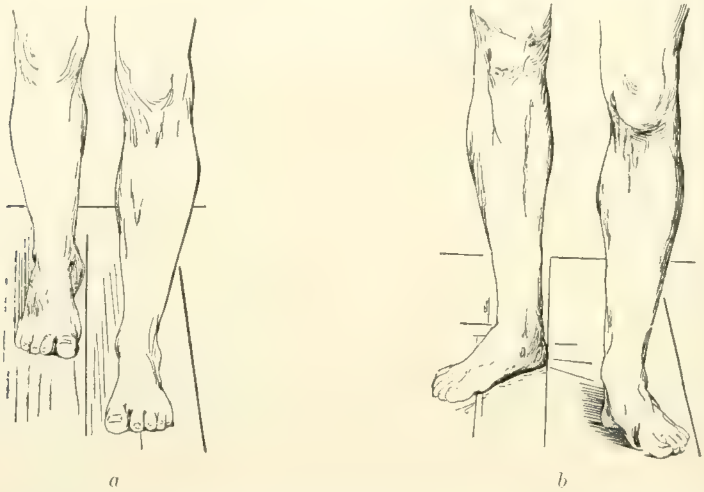


FIG. 634.—Shows Normal and Abnormal Attitudes in Walking. *a*, The proper attitude in activity, illustrating the adduction of the fore-foot when the body is lifted—the "springy gait"; *b*, the improper attitude of outward rotation of the limbs—the "heel walk."

This passive posture may be called the attitude of weakness, and flat-foot, which is simply an exaggeration of this attitude, may properly be called the weak foot. (Fig. 635.)

It is evident that weight habitually borne on the inner side of the foot must tend to break down the arch, and, in a large proportion of the cases acquired in adult life, whatever actual flatness is present was gradually acquired, induced by this habitual malposition.

On the other hand, there is a type of foot which is actually flat, as shown by the imprint of the sole. In this class the heel projects, and the bulging of the inner border is less noticeable than in the other class. A low arch of this type may be an inherited peculiarity, possibly a racial characteristic, in which case there is no discomfort. In most instances, however, it is due to weakness and laxity of the tissues in early childhood, a notable cause being rhachitis.

As has been stated, it is the process of breaking down that causes the disabling symptoms. If, then, the foot has always been flat, as in the cases mentioned, and if the component parts have become adapted to the deformity during development, the only symptoms may be the deformity and the awkward gait that usually accompanies it; whereas the process of deforming a normal foot must of necessity be long and painful.

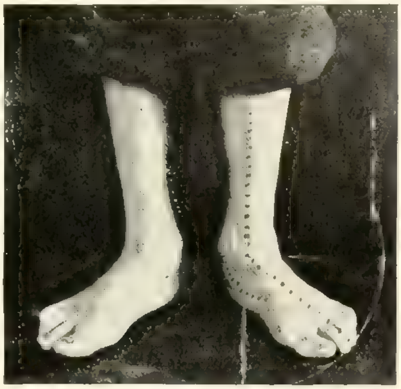


Fig. 635.—Typical Weak Feet of Moderate Degree, Illustrating the Component Elements of Abduction and Depression of the Arch.

The weak or flat foot has been defined as one in which there is an abnormal persistence or exaggeration of the passive attitude of abduction. (Fig. 636.) The most noticeable peculiarity of such a foot is the bulging of the inner border due to the inward rotation of the astragalus, which has turned downward and inward upon the os calcis. This supporting bone is also rotated slightly in the same direction and tilted so that its upper surface presents an inclined plane to favor the further displacement of the astragalus, the front of the foot being inclined outward. The astragalus supports the leg, which is therefore rotated inward, so that the line of strain now passes inside the great toe, and the weight of the body is supported almost entirely on the inner border of the foot, as is illustrated by the wear on the sole of the shoe. (Figs. 637 and 638.)

Etiology.—The weak foot is, in the great majority of cases, the result of the disproportion between the strength of the supporting structure and the weight and strain that it is called upon to sustain. For example, the foot may be congenitally weak or deformed. Its weakness may be the result of rhachitis or other form of malnutrition in childhood. It may be weakened directly or indirectly by various diseases or by injury; and, as has been stated, it is almost always weakened by improper and ill-fitting shoes.

On the other hand, it may be overburdened by an increase of body weight or by laborious occupation, or the muscles and other tissues may be temporarily weakened as the result of illness. In a great proportion of the cases, however, the strength of the foot would be quite sufficient for the work required of it, were it not that it is placed at a disadvantage by the habitual and unnecessary assumption of the passive attitude in the place of normal alternation of posture.

The foot, in spite of maltreatment, usually remains efficient; thus it is that a special exciting cause—for example, laborious occupation—is so noticeable in hospital practice, a relatively large proportion of the male patients being bartenders, waiters, and others of the class who stand much of the time. It is apparent, therefore, that the statistics of this class do not adequately represent the subject, especially so since it is discomfort and disability rather than awkwardness and deformity that account for the visit of the patient.

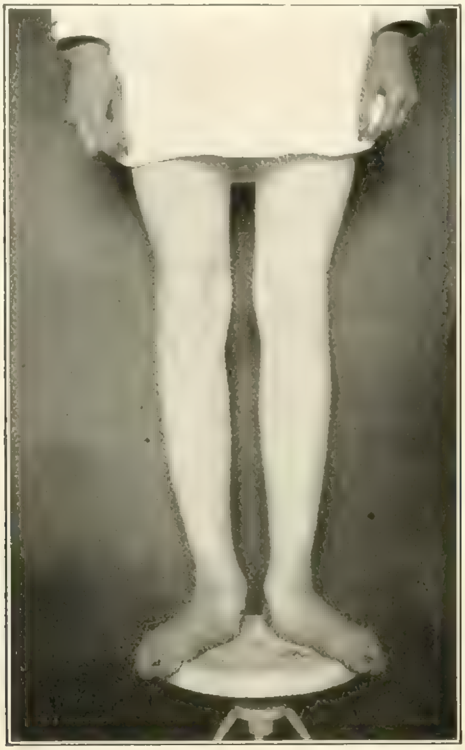


FIG. 636.—Weak Feet, Illustrating Abduction and the Attendant Depression of the Arch.

For example, 883 new patients—comprising nearly twenty per cent of the strictly orthopedic cases—applied for treatment of this affection, in 1904, at the Hospital for Ruptured and Crippled; 467 of these were males; 580 were more than twenty-one years of age and but 119 were less than fourteen years. And yet it may be assumed that the weak-foot is very common in childhood, although the symptoms of discomfort do not appear until adolescent or early adult life, a period when the strain is greatest. When they are delayed until middle life, there is usually a predisposing cause, either general or local. The affection is usually bilateral, although it often begins in one foot, appearing later in the other after the patient has for a time favored the weaker one.

Symptoms.—The symptoms of weak or flat foot, which in its inception is an abnormal persistence of the passive attitude, in which the limb has a tendency to become displaced toward the inner side of the foot, are incidental to this displacement. They are therefore usually more marked and disabling during the breaking down of a well-formed foot than in one in which the arch was originally low, since it may be assumed that a quiescent stage is reached when further displacement is impossible. This final stability in the well-formed foot would imply great lateral deformity and practically complete disorganization of the normal relations, while in the other instance it might mean nothing more than a slight increase of the habitual malposition. This explains the fact that the symptoms bear no particular relation to the degree of deformity, but are dependent upon the strain and injury to which the weakened foot is subjected. For example, in ordinary cases, there are sensations of weakness and discomfort referred to the inner side of the ankle and foot, often pain or sensitiveness in the heel in the neighborhood of the great toe or below the external malleolus and about the dorsum of the foot. As the affection progresses, the symptoms become more acute and are accompanied by muscular spasm. The patient then notices stiffness whenever he resumes activity after rest. Thus, on rising from a chair he limps or staggers until further use forces the bones back into their habitual position. Cramps in the calves and pain about the knees or in the back are not unusual accompaniments, especially in females.

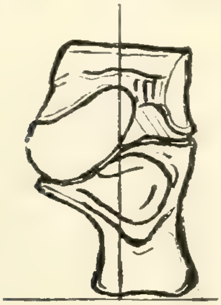


Fig. 637.

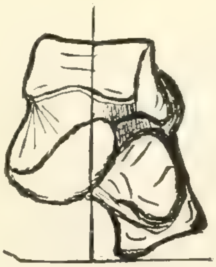


Fig. 638.

Fig. 637.—The Normal Relation of the Astragalus to the Os Calcis. (See Fig. 642.)
Fig. 638.—The Normal Relation of the Astragalus to the Os Calcis in Confirmed Weak Foot.

In cases of long duration, particularly of the rigid type of deformity, there are other symptoms of inactivity; for example, passive congestion, excessive perspiration, varicose veins, and atrophy of the muscles. The internal changes are those of accommodation to the deformity; thus, adaptive shortening and

and in the shape of the bones, varying with the degree and duration of the disability. In the ordinary type of weak-foot these organic changes are slight. In cases of long standing, on the other hand, there may be practical disorganization of the joints.

Diagnosis.—In general it may be stated that pain in the foot in the situations mentioned, increased by use and relieved by rest, is sufficiently diagnostic of local weakness, as contrasted with rheumatism or gout, for which it is so often mistaken. It is, of course, evident that these affections may induce weak-foot, or complicate it, but in the majority of cases the disability is purely local.

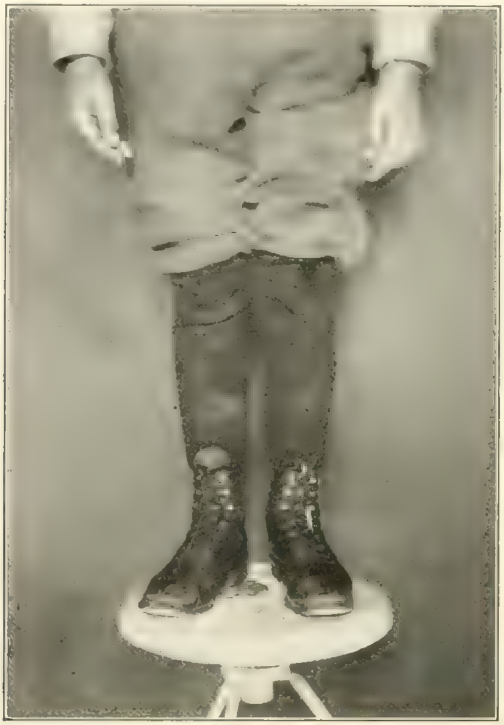


Fig. 639.—Weak Feet in Childhood, Showing the Slight Characteristic Bulging on the Inner Border, the Earliest Indication of Weakness. (Compare with Fig. 640.)

As the symptoms depend upon the strain and injury that the weakened foot sustains, they are lessened or are relieved by rest or by a change of occupation. Thus, in ordinary cases of the disability there are periods of comfort or remission alternating with those of discomfort. Usually there is an instinctive adaptation of the habits to the weakness—an adaptation that restores, as it were, the equilibrium, so that the patient is, under ordinary conditions, comparatively comfortable.

As has been stated, the disability is not proportional to the degree of deformity. Thus, in childhood, when the weight and strain are slight, awkwardness and distortion are the principal symptoms, while in adult life discomfort and pain are of far greater importance.

From the nature of the affection, then, it would appear that the earliest symptom should be an awkward walk, for, as the feet are habitually abducted, the power of the calf muscle is displaced inward in its relation to the fulcrum, and the gait is heavy and inelastic—a "heel walk." The slightly bulging inner border of the foot and the signs of wear on the inner border of the shoe have been mentioned already. (Fig. 640.)

The next step in the progress of deformity is limitation of normal motion. For example, when the passive attitude has persisted for some time, the ability voluntarily to adduct the foot is lessened, and, when the muscles have become adapted to the habitual posture, the range of passive motion is lessened also.

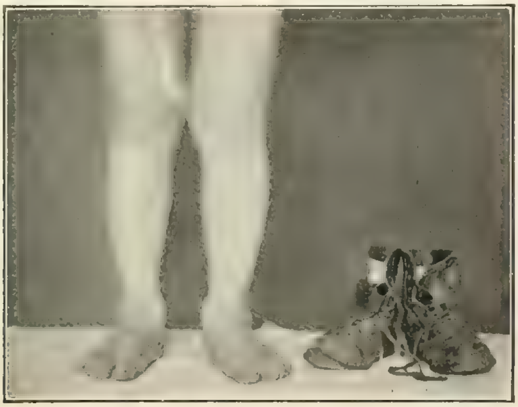


Fig. 640.—Weak Feet in Childhood. The shoes indicate the habitual attitude.

In this class of cases, of progressive and painful deformity, muscular spasm is present in a degree corresponding to the acuteness of the symptoms—a spasm which prevents movement, causing the stiffness of which the patient complains. It may be noted here that although turning of the feet outward is one of the commonest causes and accompaniments of the weak-foot in adult life, intoeing, on the other hand, is the common position in early childhood. At this period of life, nature's remedies and compensations are oftenest apparent, and the intoeing is the natural remedy both for weak-foot and for knock-knee. It is this symptom that usually first calls the mother's attention to the underlying deformity.

There are several types of the weak-foot. In childhood the deformity is very often the direct result of general weakness—for example, rhachitis. The muscles and ligaments are relaxed, and the entire sole of the foot often rests upon the floor. Such a foot is properly called flat. Another type common in older children is the so-called weak ankle, in which the arch is but little depressed, but is in a position of valgus when weight is borne, so that the malleoli interfere, and the shoe is worn away at this point.

In older subjects, there is every variety of type from discomfort without deformity to extreme deformity without discomfort. In one the pain, principally of the nature of tire and strain, is due to the assumption of improper postures. And in the early stage there may be, practically speaking, no deformity, and but slight limitation of the power to invert the foot. At the other extreme of this type, in which the arch is of normal depth, the foot may be held in a position of fixed abduction. This deformity, which is usually the result of injury, is often classed as "chronic sprain." In another class of cases the arch is completely broken down, so that the entire sole is in contact with the ground. This type, the typical flat-foot, has usually persisted since childhood. Between these extremes one finds every grade of deformity and disability; the disability, as has been stated, being dependent rather upon strain and injury than on the degree of deformity.

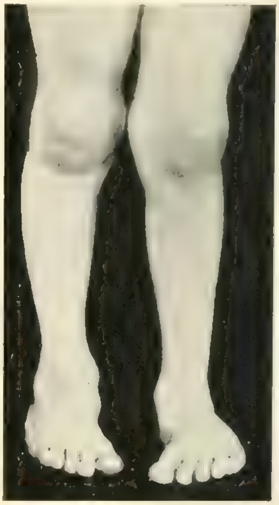


FIG. 641.—Adduction of the Fore-foot Combined with Valgus; an Uncommon Type.

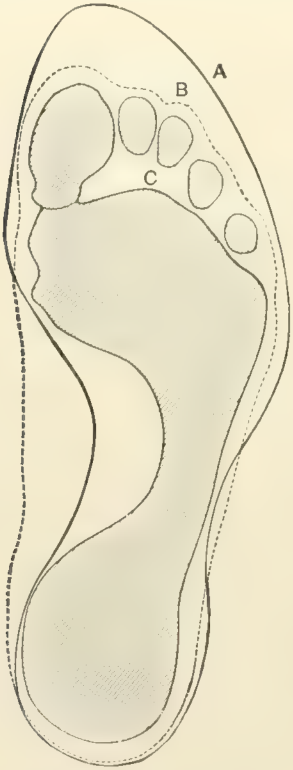


FIG. 642.—The Proper Relation of the Sole of the Shoe to the Shape of the Foot. *A*, Outline of the sole; *B*, outline of the foot; *C*, imprint of the foot.

TREATMENT.—As the so-called flat-foot is, in most instances, an acquired disability, prevention is of the first importance. This must include proper shoes, so fashioned as not to deform the foot or to cramp the toes or to weaken the muscles, and the avoidance of attitudes that favor deformity. For example, the feet should be nearly parallel in walking, and a certain spring or leverage by active use of the calf muscles should be cultivated. One should avoid also long persistence in the passive attitude, even though it is proper for the work required. For instance, if the individual must stand for long periods he should relieve the continual strain by occasionally raising the body on the toes or by throwing the weight toward the outer border of the foot. This, of course, applies to the treatment of the mild cases of weak-foot. In addition, the inner border of the heel and sole of the shoe should be made thicker (about one-quarter of an inch) and, as it were, wedge-shaped, so that the weight may be inclined toward the outer or stronger side of the foot. (Fig. 643.) The patient should assume the attitudes opposed to deformity: thus, for example, in sitting the feet may be crossed so that the weight resting on the outer borders may enforce the position of adduction.

The patient should also strengthen the adductors by voluntarily turning the feet inward over and over again to the varus attitude. (Fig. 672.) The most effective exercise is the following: the patient stands erect and turns the feet inward—the pigeon-toe attitude. He then raises the body slowly on the toes as far as possible, then slowly sinks downward, at the same time rolling the feet into the attitude of extreme varus. This exercise, which is somewhat difficult, should be carried to the point of fatigue twice daily.

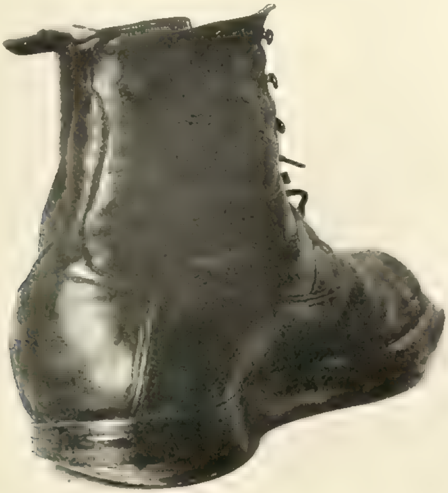


FIG. 643.—The Internal Border of the Shoe Thickened According to Thomas' Method. If braces are worn only the inner border of the heel and the inner border of the bearing surface of the sole are thickened.

If the patient is unable by voluntary effort to restrain deformity, a brace for temporary or permanent use is indicated. Such a brace should be designed actually to restrain deformity, as contrasted with the sole plates that are usually applied and that have little influence on the lateral distortion; and, as an accurate fit is essential, a plaster cast of the foot should be taken in the following manner: Seat the patient in a chair; in front of him place another chair of equal height; on it lay a thick pad of cotton batting and cover it with a square of cotton cloth. Put about a quart of cold water into a basin and sprinkle plaster of Paris on the surface until it does not readily sink to the bottom, then stir. When the mixture is of the consistence of very thick cream pour it upon the cloth. The patient's knee is then flexed and the outer side of the foot, previously smeared lightly with vaseline, is allowed to sink into the plaster, and, the borders of the cloth being raised, the plaster is pressed against the foot until rather more than half of it is covered.

The foot should be at a right angle with the leg, and the sole should be in the plane perpendicular to the seat of the chair. As soon as the plaster is hard its upper surface is coated with vaseline, and the remainder of the foot is covered with plaster. The two halves are then removed, dusted with talcum powder and bandaged together, and then filled with plaster cream. In a few moments the plaster shell may be removed, and one has a reproduction of the foot, which, when properly made, should stand upright without inclination to one side or the other. (Figs. 644 and 645.) The advantage in making the cast in the manner described is that, as the weight is supported on its outer border, the foot is placed in the proper attitude of slight adduction.

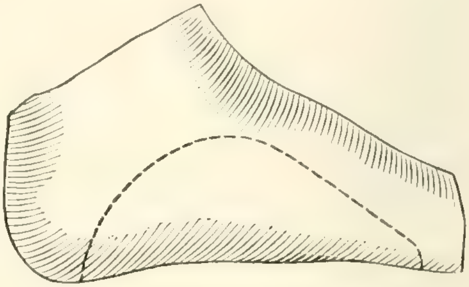


FIG. 644.—A Cast Marked for the Mechanic. The depth of the arch is not shown in the reproduction of the photograph.

In most instances it will be of advantage to deepen, in the plaster model, the inner and outer segments of the arch, in order that the arch of the brace may be slightly exaggerated, especially at the heel, and that thus the depression of the anterior extremity of the os calcis may be prevented. Upon the model the outline of the brace is drawn as illustrated in the diagram. The best sheet steel, 18 to 20 gauge, cut after the pattern, is moulded upon it and tempered, so that, as it is applied for the purpose of preventing deformity, it may be practically unyielding to the weight of the body. It may be nickel- or tin-plated, or covered with leather, according to the quality of the patient.

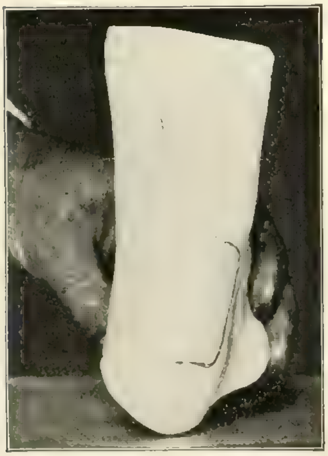


FIG. 645.—The Outline of the Sole Part of the Brace. (Whitman's "Orthopedic Surgery.")

It will be noted that this brace depends for its action primarily upon lateral support. For, as the deformity is lateral in the sense that its first indication is a projection caused by the head of the astragalus at the inner border of the foot, it should be apparent that the control of this lateral deformity is the first essential for the proper brace. It is the absence of lateral support that explains the inefficiency of the braces in common use. (Figs. 646 and 647.)

As this support fits the foot closely it must be carefully adjusted to make it comfortable. The patient is therefore instructed to use it for a short time only and then to return, so that pressure may be removed by bending the margins of the plate slightly outward where the marks on the foot indicate it. If, on the other hand, the brace projects so that its presence in the shoe may be detected, its margins may be turned inward to the proper degree. A well-fitting shoe, the heel and inner border of the sole having been thickened slightly, should always be used in order to aid the action of the brace.

The patient, instructed to walk with the feet parallel, bears the weight on the outer border of the foot. This presses down the outer border of the brace and lifts it slightly beneath the arch. This suggestive pressure is important because it is increased whenever the foot is placed in the improper attitude of outward rotation, and thus it becomes a positive aid in functional cure by preventing the improper posture. The exercises that have been described are an essential part of the treatment; for, when the muscles have become stronger and normal attitudes have become habitual, the brace in many instances may be discarded. In cases of this class it is worn usually for a period of about six months, but in chronic cases in adults brace treatment may be continued indefinitely, although, as has been stated, when pain is relieved treatment is usually discontinued by the patient. Under the use of braces combined with the exercises there is generally improvement in the shape of the foot, and in the treatment of the better class of patients it is of advantage to make a second cast after several months. It is apparent that a brace of this description requires a certain degree of care and skill both in its preparation and in its use as contrasted with sole-plates which are essentially merely metal inner soles. A cast of the sole of the foot is made, the arch being deepened if it is thought desirable, and the outline of the brace is drawn on it; the inner border is curved upward to pass just beneath the lower part of the scaphoid bone. This

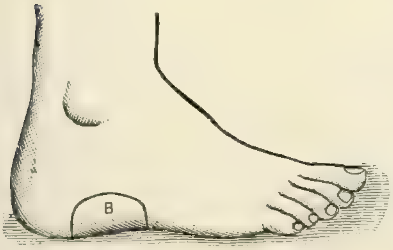


Fig. 646.—The External Flange. *B*, The calcaneo-cuboid articulation. The flange is often extended farther back than is shown in the diagram. (See Fig. 649.)

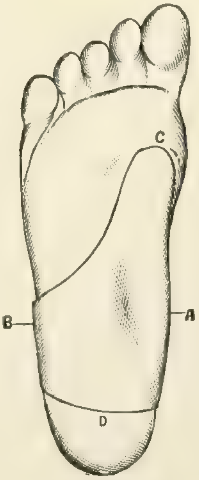


Fig. 647.—The Whitman Brace, Illustrating Lateral Support, *A*, *B*, in Addition to Direct Support, *C*, *D*. Lateral support, which checks abduction, is the more important. *A*, The astragalo-navicular articulation; *B*, the calcaneo-cuboid articulation; *C*, the metatarso-phalangeal joint; *D*, the bearing surface of the heel.

type of brace, now for sale at most shoe-shops, is so familiar that further description is unnecessary. It is ineffective in the sense that it does not control the lateral deformity and is thus a simple negative support.

In many cases of the more severe type even passive motion of the foot is resisted and painful. This resistance is due in great degree to muscular spasm, but, if the deformity is of long duration, secondary accommodative contractions of the muscles and other tissues, and changes in the articulating surfaces of the bones, may be additional complications. If the pain is acute, there is usually an accompanying infiltration about the medio-tarsal and ankle joints. In such cases rest combined with massage, hot water, hot air, and the like may be indicated. In the ordinary type, however, the resistance may be overcome gradually in the following manner: The foot is passively adducted as far as the contraction permits, and, while it is supported in this attitude, a long, wide band of adhesive plaster is passed about the foot. One end is attached just below the external malleolus and it is then drawn beneath the arch and up the inner side of the leg to the knee, with all the tension possible, and is further supported by straps about the instep, ankle, and calf, and is then covered by a well-fitting bandage, the object being to hold the foot in slight adduction and to support the sensitive part. This dressing is renewed at intervals until the foot can be adducted to the normal limit.

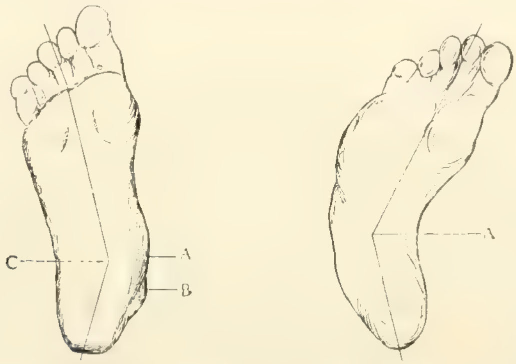


Fig. 648.—Illustrates Forcible Correction of the Deformed Foot. *A*, Scaphoid bone; *B*, internal malleolus; *C*, medio-tarsal joint.

If the foot is rigid and if the manipulation causes much pain, the best treatment is to overcome the deformity entirely at one sitting and to fix the foot for a time in the overcorrected position.

The patient having been anæsthetized, all adhesions and contractions that resist motion in any direction are then overcome; considerable and persistent force, applied by the "pump-handle" method of alternate pressure and relaxation, being necessary. The foot is then extended, adducted, and finally in the position of varus it is forced up if possible to a right angle with the leg. In other words, the deformity is overcorrected. It is then covered with a thick layer of cotton batting, and a plaster-of-Paris bandage that extends nearly to the knee is applied. In some instances the tendo Achillis must be divided and occasionally also the peronei, to permit the desired position. As soon as possible, the patient is encouraged to walk about, as the weight of the body falling on the outer border of the foot and functional use aid in correction.

At the end of from two to four weeks, provided tenotomy has not been required, the support may be discarded, but several times a day the foot should be forcibly turned inward to the limit reached under anæsthesia, otherwise the deformity will inevitably recur. Massage, prolonged soaking in hot water, rest, and the like are of course indicated, or, in default of these, the plaster strapping should be applied.

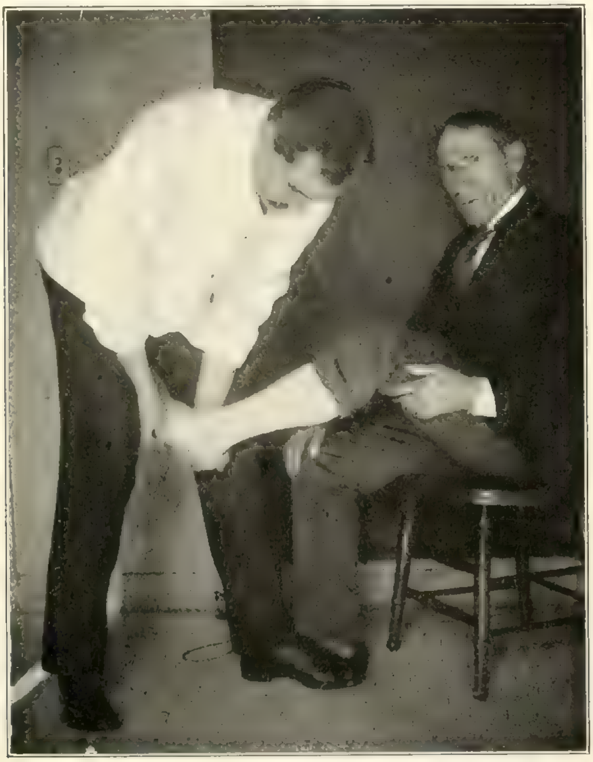


FIG. 649.—"Twisting the Foot." Forcible manual adduction, a manipulation essential when muscular spasm is present.

The daily forcible methodical manipulation to the limit of adduction, however, is the one indispensable part of the treatment. When the foot has become fairly flexible the brace is applied, and the treatment is then conducted in the manner described.

Various cutting operations have been devised for the cure of flat-foot, but they are of little value. In cases of extreme deformity of long standing, in which permanent changes have taken place in the joints, a modification of the Ogston operation may be of value in improving the shape of the foot. Under the Esmarch bandage an incision is made down and toward the sole from a point about one inch in front of the internal malleolus. This exposes the mediotarsal joint. With a chisel a wedge is removed, its base about three-quarters of an inch in width, including parts of the astragalus, and the foot is then forced inward so that the wedge-shaped gap is closed, the wound is sutured, and a plaster bandage is applied. A brace should be applied when union has taken place.

It may be mentioned in conclusion that, although the symptoms of the weak-foot are often mistaken for rheumatism and the like, yet the two affections may coexist or the deformity may be the result of the general disease. In such cases local support is indicated whenever discomfort is caused by use, but it must, of course, be supplemented by appropriate internal remedies and by hygienic treatment.

Weakness and Depression of the Metatarsal Arch; Anterior Metatarsalgia and "Morton's Toe."—The metatarso-phalangeal region of the foot forms, when weight is not borne, a slight arch, highest at the second joint. As an effect, in most instances, of shoe-wearing, the toes being held in a cramped position, this arch is permanently depressed, the front of the sole of the foot having a convex or rounded contour.

Thus the weight is borne entirely on the metatarso-phalangeal joints, the dorsiflexed toes having lost their function as accessory supports. The most common and direct effect of the abnormal pressure is a painful callus that forms beneath the heads of the second and third joints, but an indirect symptom of the deformity or weakness is neuralgic pain referred to this region; hence the name anterior metatarsalgia.

As regards the deformity, it should be stated that its degree has no particular relation to the pain and discomfort. In one instance the toes may be fixed in dorsiflexion and the arch rigidly depressed; in another case there is a general relaxation of all the tissues, so that the front of the foot may appear abnormally broad when weight is borne; while in a third the foot may appear to be almost normal, and yet the disability is much greater than in the preceding types.

Morton's Painful Toe.—The most common and characteristic variety of anterior metatarsalgia is that first described by Morton, of Philadelphia, in which pain is referred to the fourth toe. This is usually sharp and cramp-like, most marked in the interval between the third and fourth joints, and radiating to the end of the toe. It is often preceded by a pricking sensation beneath the toe, by burning or numbness, and occasionally by a sensation as if the joint were displaced. It begins usually as a burning or numbing pain, sometimes most severe in the end of the toe, that increases in severity unless it is relieved by removing the shoe. If it is severe it is sometimes followed by redness and swelling about the affected articulation and it may radiate up the leg.

The pain in the majority of cases, although according to the patients it has a variety of predisposing causes, is induced directly by the shoe, and it is the imperative need to remove the shoe, wherever the patient may be, that is one of the most noticeable characteristics of the affection.

The affection is somewhat more common in females than in males and often several members of a family or two successive generations may be sufferers. The pain may be experienced only at long intervals and may be induced by a particular shoe, or it may come on at such frequent intervals as practically to disable the patient.

Symptoms and Causes.—The first symptom may be ascribed to injury or to overuse of the foot, but, as a rule, no cause can be assigned. Formerly it was looked upon as a rather mysterious affection, but at the present time its causes and treatment are comparatively well understood.

The direct cause of the peculiar pain, as I have endeavored to explain elsewhere, is lateral pressure upon the depressed metatarso-phalangeal joints. This is illustrated by a similar pain if the hand is suddenly pressed while the fifth metacarpal bone is elevated above the fourth, or if the metacarpal bones are on the same plane; whereas, if the arch is elevated so that the bones are guarded from pressure, the hand may be tightly squeezed without discomfort.

The pain is most common at the fourth articulation of the foot because of the mobility of the fifth metatarsal bone and because the toe is usually elevated by the narrow shoe above the level of its fellows. The pressure comes more or less directly upon the nerves lying between the joints and upon the sensitive tissues that are bruised by the pressure and friction.

The pain, although far more common at the fourth joint than elsewhere, may affect any joint or combination of joints, corresponding to the deformity and weakness, but if the pain is diffused, the front of the foot is almost always depressed and often in a condition of rigid deformity, a sequel, for example, of rheumatism or similar infection.

Treatment.—In the milder cases the symptoms cease if a proper shoe is provided—one that allows room for the toes, that fits well beneath the arch, and that holds the foot securely. Massage and alternate flexion and extension of the toes for the purpose of strengthening the muscles and restoring the flexibility of the arch are of advantage in the treatment of any stage of the affection.

As a temporary treatment of the more painful cases, the arch having been restored by elevation of the painful joint, the metatarsus may be supported by a wide band of adhesive plaster passed directly about it, the aim being to hold the foot as the hand is held by a tight glove. The position may be still further assured by placing a small pad of felt or leather beneath the painful joint. Many patients habitually use a bandage for the same purpose.

The best treatment, however, is by a properly fitted metal plate. A plaster cast of the sole is made and in the model sufficient plaster is cut away beneath the depressed region to represent a well-marked arch, deepest beneath the affected joint. On this, a thin metal plate is moulded. The brace should fit the entire sole, supporting the longitudinal arch in order to distribute the weight properly, and in well-marked cases it should extend from the extremity of the heel somewhat beyond the metatarso-phalangeal articulations in order to prevent dorsal flexion of the toes. When the foot has been supported for a time the sensitiveness subsides, and if exercises (Fig. 651) are employed and a proper shoe provided, the patient may in a few months discard the brace.

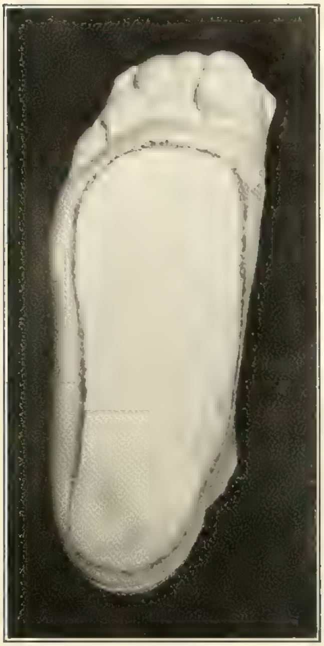


FIG. 650.—Plaster Cast of the Sole of the Foot Marked for the Mechanic. This brace is designed to elevate the anterior arch and to limit motion at the sensitive metatarso-phalangeal articulations. It is more effective than the form shown in Fig. 652.

If, as in many instances, dorsal flexion of the toes is persistent, and is accompanied by stiffness of the forefoot, forcible manipulation and massage may be essential to restore the normal elasticity. In the most severe cases, such as may follow gonorrhœal infection and the like, forcible manipulation under ether, with subsequent fixation for a time in a plaster bandage, may be indicated.

Complications, such as the contracted or flattened foot and the like, should of course receive attention.

Operative Treatment.—This in typical cases consists in the removal of the head of the fourth metatarsal bone—that is, of the point against which pressure is exerted. The operation may be done under local anæsthesia. An incision about one inch and a half in length is made on the dorsal surface over the articulation. The joint is then forced upward, by flexing the toe, the capsule is divided, and the head of the metatarsal bone, being exposed, is pushed through the wound and is removed at the neck by bone-forceps.

If the tissues are sensitive it is well to apply a plaster bandage which supports the toes and sole. The temporary use of a sole-plate is of advantage. As a rule, the operation relieves the symptoms, the foot is not perceptibly weakened, and the only deformity is slight recession of the toe.

Now that the cause of the trouble is better understood than in Morton's time, it is often recognized and relieved in its inception, and therefore operative treatment is far less often indicated.

In many instances there is no spasmodic or neuralgic pain of the character described which may be relieved by removal of the shoe; instead, there are stinging, burning pains which are referred to the front of the sole, and which are due, as has been stated, to abnormal pressure on a depressed anterior arch. In such cases the sole-plate, combined with manipulation and exercises to increase the range of plantar flexion of the toes, usually assures relief.

If a painful callus or corn or papilloma is present, it should be removed before the support is applied.

Achillo-Bursitis.—A bursa is interposed between the insertion of the tendo Achillis and the os calcis. Irritation or inflammation of this bursa causes local sensitiveness and, secondarily, loss of function of the calf muscle. Occasionally, the cause may be pressure of the shoe, or direct strain upon the tendon in violent exercise, but in many instances it is a complication of infectious disease, such as rheumatism or some similar affection, and particularly of gonorrhœa.

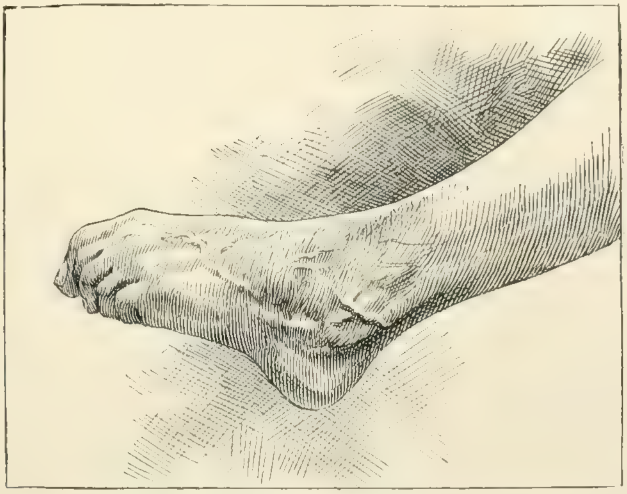


Fig. 651.—Plantar Flexion of the Toes, an Exercise for Strengthening the Anterior Arch and Overcoming Deformity.

In traumatic cases the affection is usually unilateral, but in the ordinary type both bursæ are often involved.

Symptoms.—The direct symptoms are sensitiveness to pressure about the insertion of the tendon, and in early cases slight swelling and fluctuation are perceptible on the inner side. In cases of long duration, however, the entire posterior part of the heel is broadened and thickened, an indication that the tissues about the bursa have become involved in the inflammation. The indirect symptoms, which are due to the loss of leverage of the calf muscle, are these: an inelastic gait with turning out of the foot, and an attitude which in turn induces pain in the bottom of the heel from direct pressure, and predisposes to weakness of the longitudinal arch. In fact, the symptoms of so-called flat-foot usually accompany those of Achillo-bursitis of long standing.

As the painful part is constantly exposed to strain and injury, the affection, particularly if induced by gonorrhœa, is of a chronic character with but little tendency toward recovery.

Treatment.—Treatment should assure rest of the affected part. In mild and recent cases, a long band of adhesive plaster may be applied along the sole and up the back of the limb, with the foot in slight plantar flexion. This, when reinforced by other adhesive bands about the foot and ankle, serves to check dorsal flexion and at the same time to provide pressure on the swollen part.

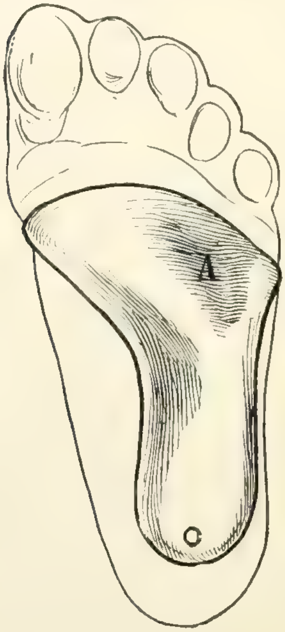


Fig. 652.—A Brace to Support the Anterior Arch of the Foot. *A*, The point of greatest elevation beneath the painful part. (See Fig. 650.)

If the case is of greater intensity, a plaster bandage is of service to fix the part until a cure is attained.

In the more chronic type a brace, provided with a stop joint to prevent dorsal flexion, may be attached to the shoe. The sensitive heel may be cauterized and strapped with the aim of hastening resolution.

As has been stated, if the affection has persisted for some time there is usually an accompanying depression of the arch, for which a brace and other appropriate treatment may be used. It is needless to add that the treatment of other complications, particularly the gonorrhœa so often present, is essential.

In chronic cases in which the bursa is enlarged and thickened, or when palliative treatment has failed, operative removal is indicated. This is easily accomplished by an incision made usually on the inner side of the tendon. Thickened and sensitive tissues in the neighborhood should be removed at the same time. A plaster bandage or supporting brace should be used until all sensitiveness has disappeared.

Pain in the Heel.—Pain, or particularly sensitiveness when weight is borne, referred to the centre of the heel, is, in most instances, a symptom of abnormal pressure. Thus it may be induced by simple overwork, particularly long standing. Most often it is indicative of the weak foot, or it may be a symptom of the hollow foot, in which the weight is supported entirely on the heel and metatarsal region. Pain in this region is common when weakness of the foot is induced by general diseases such as rheumatoid arthritis or by gonorrhœa, in which cases there may be a local inflammation about the insertion of the plantar fascia or deep ligaments. In rare instances a sensitive bursa, secondary, it may be, to an exostosis of the os calcis, or even a neuroma, may be present. In such conditions, or when gonorrhœal inflammation or the like is the exciting cause, the sensitiveness is much greater and more localized than when the discomfort is due to simple pressure.

If the condition is inflammatory, rest, as secured by the application of a plaster-of-Paris bandage, is indicated. If the pain is simply localized and persistent, and particularly if it persists in spite of support, or if an actual exostosis, as indicated by an *x*-ray picture, is present, operative removal is indicated.

In most instances, however, the symptoms may be relieved by treating the condition which induces it, namely, the weak-foot. In mild and early cases the use of a rubber heel and the cultivation of a "toe walk" may be sufficient, but in most cases a well-fitting metal sole-plate, fashioned on a plaster cast sufficiently high under the arch to transfer to this point part of the weight, or, in other words, to distribute the pressure on the foot, is indicated as a primary measure.

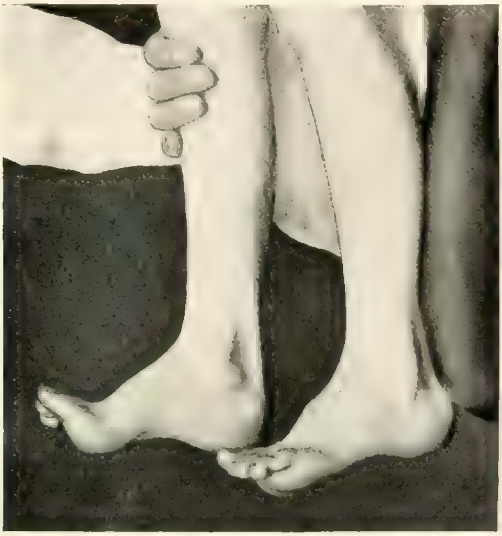


FIG. 653.—The Contracted Foot—an Exaggerated Arch and Slight Limitation of Dorsal Flexion.

The Hollow or Contracted Foot.—The depth of the arch varies in different individuals, and a high arch as contrasted with a so-called flat-foot is, from the æsthetic standpoint, usually considered desirable.

As a rule, however, the high arch is accompanied by a certain inflexibility that predisposes to discomfort. There is, for example, difficulty in procuring shoes that fit the sole, and the weight and strain are concentrated upon the heel and front of the foot, thus predisposing to corns, calluses, and pain in the metatarso-phalangeal region and to discomfort about the arch. There is also in these cases a tendency toward valgus; thus the patient with hollow-foot may suffer from the characteristic symptoms of the so-called flat-foot.

In the more extreme cases of this type there may be limitation of dorsal flexion at the ankle due to shortening of the calf muscle, a type to which Shaffer has called attention.

The hollow foot may be congenital. It is favored by the habitual use of high heels. It may be induced by habitual posture, as by illness in which plantar flexion of the feet is favored by the weight of the bed clothing. It may be a result of neuritis or of a very limited anterior poliomyelitis sufficient to weaken the anterior muscles. In this class there is usually a slight degree of equinus.

Symptoms.—As has been mentioned, the symptoms in the milder cases are due to the rigidity of the foot and to the pressure of the shoe on the projecting dorsum. If dorsal flexion is limited, cramps in the calves also are often troublesome.

Treatment.—For mild cases a well-arched shoe to equalize pressure is sufficient. If, however, the plantar fascia is sensitive to pressure, a light metal support made on a plaster cast to support both the longitudinal and metatarsal arch may be essential.

Forcible manual or instrumental stretching of the foot and forced dorsal flexion may be of service in lessening the contractions in cases of the milder type.

If there is abnormal contraction of the plantar fascia, and especially if there is accompanying shortening of the calf muscle, the most effective treatment is correction under anæsthesia.

The foot being dorsiflexed, the contracted fascia is brought into prominence, and it may be easily divided at the centre of the foot subcutaneously. The contraction may then be further reduced by stretching with the Thomas wrench. If the resistance to dorsal flexion still persists, the tendo Achillis may be divided. The foot is then fixed by a plaster bandage, the patient being allowed to walk about as soon as the discomfort has subsided.

The after-treatment consists in the use of a proper shoe and massage, and stretching of the foot for a time to assure the improvement.

Hallux Varus and Pigeon-Toe.—Hallux varus, in which the toe is somewhat adducted, is practically always a congenital peculiarity. The great toe stands away from the others and catches when the stocking is drawn on. In many instances of this class there is a slight degree of congenital varus.

If the toe alone is affected, wearing of the shoe may be counted upon to assure a cure, or, if the movements of the toe may be restricted, relief may be obtained by binding it to its fellows by an encircling band of adhesive plaster. If the adduction of the toe is complicated by varus deformity, the foot should be straightened by apparatus or by plaster bandages, as described elsewhere.

Pigeon-Toe.—Pigeon-toe is the popular name for an intoeing gait of which hallux varus may be the cause, as may other varieties of talipes. So also it may be a direct result of a spiral twisting of the tibia in bow-leg. In most instances, however, it is symptomatic or compensatory, usually for weak feet or for knock-knee, and one should always examine the patient for such weakness before treating the attitude, which in such cases is a conservative effort of nature to protect the patient.

If, therefore, the attitude depends upon direct deformity of the foot and limb, or if it is symptomatic of weak feet or knock-knee, treatment must be directed to its cause. In those cases in which the intoeing is apparently a simple habit, the sole of the shoe may be made slightly thicker on the outer border, and, as has been mentioned in the section relating to treatment of club-foot, bands of elastic tape may be attached to the outer border of the front of the sole of the shoe, and carried round the back of the calf to the knee, outward over the front of the thigh to the back of a waist belt, sufficient tension being exerted to rotate the foot outward and to lift slightly its outer border.

Hammer-Toe.—Hammer-toe is a contraction deformity in which the first phalanx is dorsiflexed, the second plantar-flexed, and the third either flexed or extended. Thus the dorsal surface of the first interphalangeal joint projects above the level of the other toes, and the toe is compressed laterally by its fellows while the extremity is expanded under the influence of pressure, the appearance justifying in some degree the name hammer. The discomfort is due to the pressure of the leather of the shoe upon the dorsal surface of the projecting joint and to the pressure of the sole upon the extremity of the toe. Thus a corn and bursa or an inflamed or ingrown toenail often make walking difficult.

The term hammer-toe is usually limited to the deformity of a single toe. In rheumatic cases or in some forms of paralysis, all the toes may be deformed in like manner. This condition is considered under "Metatarsalgia" (p. 886).

The cause of the deformity, although it may be congenital, is in most instances the shoe, which is too narrow and too short. Thus the second toe, which from the length and situation is most directly exposed to the pressure of a short shoe and to that of the great toe, which is forced into valgus deformity, is usually involved.

Treatment.—This, of course, includes prevention. The patient should be provided with a proper shoe which will allow sufficient space for the toe. For the treatment of the slighter grades of deformity in children, manual correction of the deformity or the use of a splint of thin celluloid or other light material passing along the plantar surface may be employed, but in the ordinary cases in adults operative treatment is indicated.

This consists essentially, after thorough stretching of the contracted parts, in resection of the first phalangeal joint, sufficient bone being removed from each phalanx so to shorten the toe as to prevent vertical pressure even if the deformity recurs. The joint may be conveniently opened laterally, and the extremities of the bones removed by forceps. The toe is straightened and a splint is applied to fix it until fibrous ankylosis is assured.

Other distortions of the smaller toes, contractions, overlapping, and the like, if seen in early childhood or infancy, may be treated by manipulation. Cure will be hastened if the toes are held in line by a strip of adhesive plaster passing above the elevated and below the depressed toe.

Hallux Valgus and Bunion.—Hallux valgus is a deformity resembling knock-knee. The first metatarsal bone is turned inward so that its head is separated from the adjoining bone while the toe itself is forced outward against its fellows. Hallux valgus is thus a subluxation in which the inner condyle of the metatarsal bone is exposed, forming a prominence on the inner border of the foot, which is subjected to the constant pressure of the shoe. The front of the foot is broader than normal and the metatarsal arch is, as a rule, depressed. The toe may be twisted on its axis in extreme cases, lying above or below the others, which in turn follow the same general outward inclination.

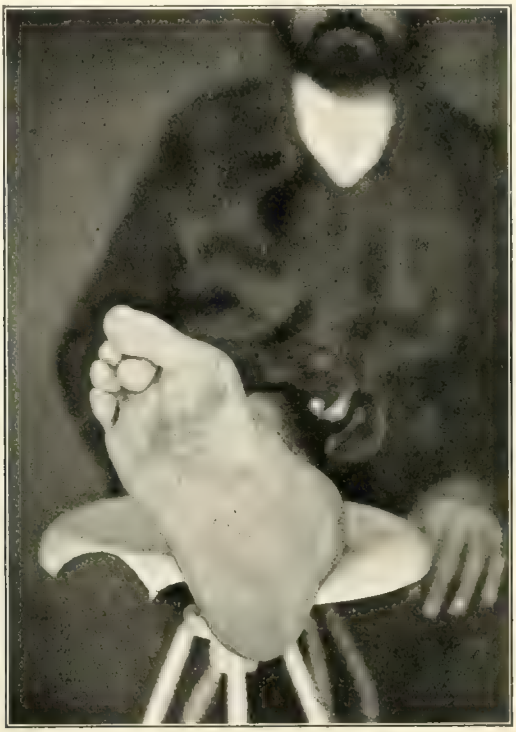


Fig. 654.—Hammer-toe and Flat-foot.

Etiology.—Hallux valgus, in slight degree at least, is almost universal among shoe-wearers, and it is common even in early childhood. The ordinary shoe is too narrow, and the inner border, instead of following the normal contour of the foot, is curved outward so that deformity is inevitable. Weakness and depression of the longitudinal or anterior metatarsal arch are predisposing causes; so also gout, rheumatism, and the like may aggravate the deformity and its symptoms.

In cases of long standing, in which there have been repeated inflammations, the underlying bone may be eroded and irregular and thus the discomforts of pressure may be increased.

Symptoms.—Aside from the noticeable deformity, the principal symptom is the discomfort caused by the pressure. This often causes a bursa over the articulation, surmounted by a callus or corn. The corn is always sensitive, and at times there is inflammation of the underlying bursa, the joint then being reddened, swollen, and so painful and sensitive to pressure as to incapacitate the patient. As incidents of the deformity are displacement of the tendons to the inner side and more or less resistant contractions.

Treatment.—In all cases a proper shoe should be provided that will relieve pressure on the sensitive parts, and, if there is depression of the arch of the foot, a suitable brace should be applied.

In connection with the shoe, methodical manipulation of the toe in the direction of adduction, combined with active exercises of the weakened muscles, will in some degree restore symmetry.

Various appliances for straightening the toe have been used, but they are, as a rule, too uncomfortable to be tolerated. One of the simplest is the Holden toe-post, a padded metal upright which is fixed to the sole of the shoe or inner sole and passes between the first and second toe to hold the former in proper position. Moulded rubber pads which cover the joint and protect the sensitive part from pressure are also used with advantage.

Operative Treatment.—The most satisfactory treatment is by operation, the object being primarily to restore symmetry. The best operation for ordinary cases is the simplest.

The patient having been anæsthetized, the toe is first vigorously stretched to overcome the contractions. A slightly curved incision, with the convexity downward just below the most prominent part of the joint, is made, the flap is turned outward, and the bursa, if present, is removed. The capsule is then split longitudinally, and the projecting part of the metatarsal bone, usually the inner half of the head, is removed with a thin chisel. The capsule and the overlying tissues are then united with fine catgut, and a plaster bandage is applied in such a manner as to hold the toe in the corrected attitude. This is retained until the wound is healed and until the sensitiveness has subsided. If the wound is properly closed, and if it heals by first intention, there is no danger of a sensitive scar or of subsequent ankylosis.

A proper shoe, manual correction, and voluntary exercises of the disused muscles will practically cure the deformity. If weakness of the arch is present, a flat-foot brace should be used.

In cases of extreme deformity, excision of the head of the metatarsal bone may be advisable. The incision may be made from the outer side or over the joint, as seems desirable, and the head of the bone should be resected by cutting-forceps or a saw. The removal of the bone accommodates the part to the shortened tissues, and the result is often a surprisingly symmetrical foot, which does not appear to be materially weakened by the removal of the bearing surface of the metatarsal bone.

Hallux Rigidus.—In this affection there is marked stiffness at the joint of the great toe, the resistance to motion being particularly to dorsal flexion. The toe, in fact, may be persistently flexed so that the head of the metatarsal bone forms a prominence on the dorsal aspect of the foot. There is usually persistent discomfort, which is increased by dorsal flexion.

The cause may be direct injury to the toe,—for example, "stubbing the toe," —but in many instances the affection is an accompaniment of a weakened longitudinal arch.

Treatment.—If the stiff toe is induced by a weakened arch it will be remedied by treatment directed to its cause. Otherwise the treatment is rest and support. For example, a very thick stiff sole for the shoe, strengthened, if necessary, by the insertion of a strip of steel, may be constructed, or, better, a moulded metal inner sole, extending from the heel to a point beyond the sensitive joint, may be worn. This, by preventing motion, relieves the discomfort and assures the necessary rest. In extreme cases it may be well to stretch the contracted tissues under ether, and to fix the toe by a plaster-of-Paris bandage in an attitude of dorsal flexion.

Under proper treatment the symptoms are usually quickly relieved.

Painful Great-Toe Joint.—Pain about the joint, especially at the inner aspect, is often induced by pressure of the leather of an improperly shaped shoe, and it is a frequent accompaniment of a weakened arch. These points should be considered before the discomfort is ascribed to gout or similar disease.

The remedy is obvious. In cases of the more extreme type, resembling the distortions of arthritis deformans, resection of the joint may be indicated.

VII. DISTORTIONS OF THE FOOT.

Talipes.

The deformities of the foot are grouped under the term "Talipes." Any form of talipes is simply an abnormal persistence of a normal attitude, or rather, in most instances, an exaggeration of a normal attitude, the centre of deformity being a centre of normal motion.

For example, the ankle joint permits, practically speaking, only vertical motion. Persistent extension of the foot on the leg (plantar flexion) is called "Talipes equinus" (horse-like), because the patient walks upon the front of the foot.

Persistent dorsal flexion throws the heel downward; hence the term "Talipes calcaneus" (from *calcaneum*, the heel bone).

The centres of inversion and eversion are the mediotarsal and subastragaloid joints. The turned-in, or adducted, foot, in which the weight is borne upon the outer border, is called "Talipes varus"; the opposite deformity, or persistently everted foot, is called "Talipes valgus."

If the deformity has persisted for some time or is extreme, two varieties are usually combined. Thus, the extended or flexed foot is often inverted or everted, hence the terms equino-varus or calcaneo-varus. There are four simple forms of talipes, namely:

Talipes equinus;
Talipes calcaneus;
Talipes varus;
Talipes valgus;

and four combined forms—

Talipes equino-varus;
Talipes equino-valgus;
Talipes calcaneo-varus;
Talipes calcaneo-valgus.

In the various forms of talipes the arch of the foot may be increased or diminished. It is, for example, increased usually in equinus and calcaneus, and diminished in valgus, the change being incidental to the more important deformity. The simple hollow or contracted foot (cavus) and the flat foot (planus) are described in another section.

Etiology.—The cause of talipes is more important than its form. Thus, from the remedial standpoint, the deformities are divided into two classes—congenital and acquired.

Congenital talipes is usually a simple deformity and is thus capable of cure. In the majority of cases of acquired talipes, on the other hand, the cause is paralysis; while, therefore, the deformity in these cases may be overcome, perfect cure is, of course, impossible.

Congenital talipes is spoken of as a simple deformity because the foot, having been fixed or constrained in its movements before birth, has become deformed in its development. In rare instances the distortion may be complicated by or caused by paralysis—for example, as an accompaniment of certain classes of spina bifida,—or bones of the foot or limb may be lacking or malformed; but in the great majority of cases there is no complication that prevents perfect cure.

That the cause of the deformity is abnormal constraint is often demonstrated in infants seen soon after birth, by the attitude of the limbs and by the adaptation of the feet to each other and by the evidence of pressure where the parts have been apposed.

The cause of the abnormal constraint is, of course, problematical. In a small proportion of the cases the influence of heredity is clear. In a few others, some abnormality of the mother—for example, a uterine tumor—is an apparent explanation, but in most cases no cause can be assigned.

The theory of Eschricht and Berg is that in the early months of intrauterine life the usual attitude of the limbs is one that predisposes to club-foot; that is, the thighs are flexed on the abdomen, the legs are crossed, and the feet are plantar-flexed and adducted. Normally the attitude changes in the later months until the feet are in the reverse position, namely, abducted and dorsiflexed. If for any reason this rotation is checked, the abnormal constraint induces deformity. The most resistant deformity is thus equino-varus, because its development begins in the early months of fœtal life, while valgus and calcaneus, representing constraint at a much later period, are, as a rule, very easily cured.

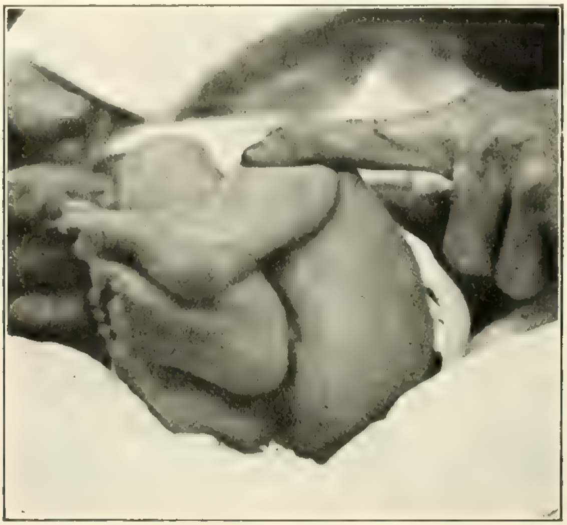


Fig. 655.—Congenital Talipes, Illustrating the Attitude of the Limbs at Birth.

This theory, although not supported by actual investigation of fœtal attitudes, is, from the clinical standpoint, very satisfactory.

Congenital talipes is much more common in males than in females, the proportion being about 64 to 36. It is more often unilateral than bilateral, the proportion being 57 to 43.

By far the most common of the congenital deformities is equino-varus, more than 75 per cent of the cases being of this type; valgus, varus, and equinus, in the order named, accounting for 15 per cent of the remainder.

The Relative Frequency of the Different Forms of Congenital Talipes.—(From Whitman's "Orthopedic Surgery.")

	Cases.	Percentage.
Equino-varus	1,272	77.0
Valgus	123	7.4
Varus	85	5.1
Calcaneo-valgus	52	3.1
Equinus	40	2.4
Calcaneus	28	1.7
Equino-valgus	28	1.7
Calcaneo-varus	7	
Cavus	5	
Valgo-cavus	1	
Equino-cavus	1	
Different deformity in each foot	18	
Total	1,660	

Talipes Equino-varus.—This form of deformity, in which the foot is turned downward and inward and even backward, explains the popular name "club-foot." In most instances only the exaggerated adduction and inversion are apparent, the equinus being masked until the foot is replaced in an approximately normal relation to the leg. For this reason it is often classified in foreign text-books as varus.

If one considers the deformed foot as having developed in the distorted attitude, it will be apparent that all its component parts must participate in the deformity. For example, all the tissues on the convex, or longer, side are elongated, and those on the concave side are too short to permit the normal position.

The bones themselves conform to the deformity and the joints are, of course, accommodated to it. The most noticeable abnormalities are in the astragalus and os calcis; the neck of the former is somewhat elongated and is twisted downward and inward, while the os calcis is usually correspondingly twisted so that its inner border is somewhat concave. At birth the deformity varies in degree and in resistance according to the duration and degree of the intra-uterine constraint. In some cases it may be nearly overcome by manipulation. In other instances it is but slightly influenced by ordinary pressure, and the foot seems smaller and thicker than normal.

If the deformity is not treated, it is, even in infancy, increased by muscular action, because motion is possible only in the directions of deformity.

When the child begins to walk, the weight of the body and functional use fix and exaggerate the distortion. The limbs are atrophied, the feet remain undeveloped, and usually the soles face almost directly backward, the centre of what corresponds to the heel being somewhat in front of a point about half way between the extremity of the external malleolus and the sole. And here a large bursa forms. There is usually compensatory knock-knee as well. In some instances, although the gait is awkward and the deformity very noticeable, the functional ability is fair, the principal discomfort being from calluses and corns.

Treatment.—The principles of treatment are very simple. As the foot has, from an early period, developed into deformity, as soon as is practicable after birth it should be made to grow toward symmetry.

In the early months of life the tissues are yielding, growth is rapid, and under favorable conditions a club-foot should be practically cured without operation before the child begins to stand. The ordinary time for beginning treatment is at about the end of the second week, although the foot may be straightened manually from time to time before positive treatment is begun.

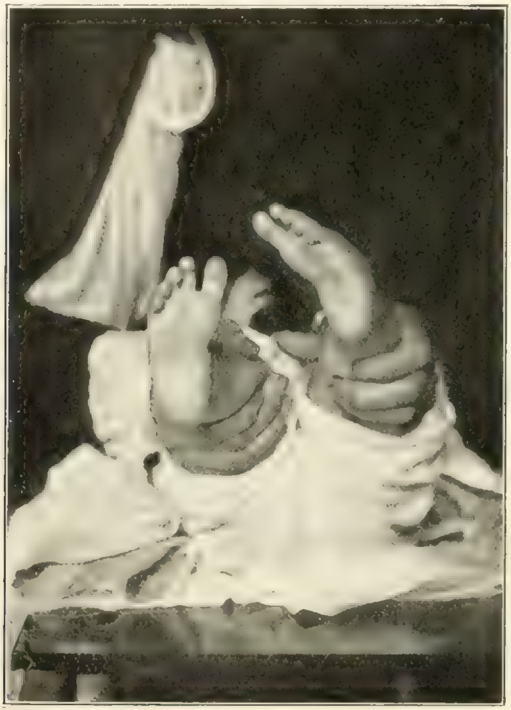


Fig. 656.—Congenital Varus without Equinus.

The first step is to overcome deformity. This deformity may be divided into three parts, which should be treated consecutively—adduction, inversion of the sole, and finally the equinus.

The most convenient means of fixing the foot during the process of correction is by a plaster-of-Paris splint. This is applied as follows: The foot is powdered, pledgets of cotton are inserted between the toes, a narrow band of cotton is placed about the toes to protect them from pressure and a similar band is placed about the calf below the knee.

The foot is then gently drawn outward until resistance is encountered and a narrow cotton-flannel bandage is applied, which in turn is covered smoothly with about two layers of plaster bandage, turns being made from without inward so that the tension may aid in retaining the foot in the improved position. This bandage should be rubbed until it is firm, the aim being to make the support no thicker than blotting paper and thus to hold the foot in the improved position without compression. At the end of a week the bandage is removed, the leg is massaged and powdered, and the bandage is reapplied with the foot in an attitude of further correction, the aim being to turn it gradually and gently at successive sittings from exaggerated adduction to exaggerated abduction. A marked improvement is readily attained at each application of the support, because the fixation diminishes the muscular resistance and because the rapidly growing part conforms to the new position. As the foot passes the line of the leg, the inverted sole becomes level, and with each application it is everted until it finally looks almost directly outward. If the limb is so fat that the support is easily displaced a narrow strip of adhesive plaster should be applied to the outer border of the leg, the lower end of which is incorporated in the bandage, and it thus serves to fix it securely in place.

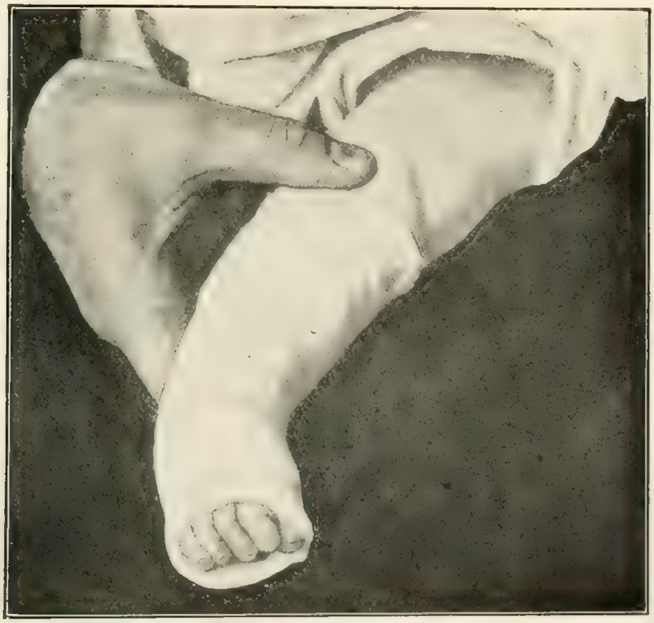
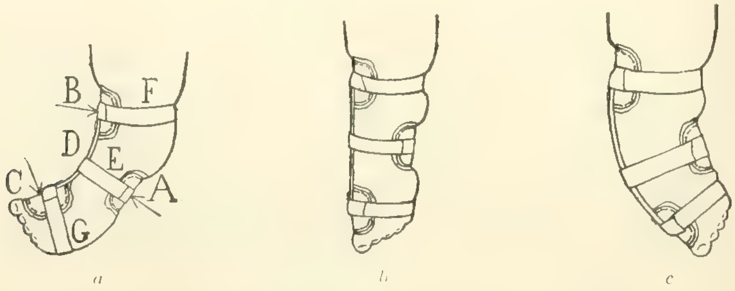


FIG. 657.—The First Application of the Plaster Bandage, Showing the Improved Position of the Foot. (From Whitman's "Orthopedic Surgery.")

In a case of moderate resistance, one should be able to change adduction and inversion to extreme abduction and eversion in from three to six treatments.

During this period sufficient tension is brought upon the posterior tissues to lessen the equinus, and when the lateral distortion, the most important part of the deformity, is corrected, the foot is brought more toward the line of the leg and is pushed upward to bring direct tension on the posterior tissues, care being taken that too much strain shall not be brought upon the leg bones and also that, as the forefoot is pushed up, the heel shall correspondingly descend. This is continued at the successive treatments until the dorsum of the foot can be forced into contact with the limb. Thus, in a favorable case, all resistance to complete overcorrection of deformity should have been overcome in about three months. This implies, of course, that the treatment has been progressive. It is sometimes suggested that the confinement of the foot is harmful, but as a matter of fact it is an essential part of the treatment, since the muscles on the back and inner side of the limb are relatively hypertrophied, and, if motion of the foot is allowed, the deformity is increased and cure is delayed. The object of treatment, furthermore, is not merely the correction of deformity, but such a transformation of the structure of the foot as will assure permanent cure. If the treatment is conducted in the manner described and if the correction is attained within a reasonable time, there is absolutely no danger of muscular atrophy other than as a temporary indication of disuse.



a *b* *c*

Fig. 658.—Apparatus of Dr. A. B. Judson for Rectification of Deformities of the Foot. *a*, The deformed member. The letters *A*, *B*, *C* indicate the points for pressure and counter-pressure. *b* shows the apparatus, *B C D* being a bar of thin brass, to either end of which are attached thin disks of the same material; a third disk, *A*, is used to equalize the pressure. The application of the splint to the limb by means of bands of adhesive plaster is shown in *c*. The correction of deformity is effected by changing the shape of the brace.

The plaster-bandage method has been described as the most convenient and effective, but other means of correction and fixation may be employed. For example, Judson uses a splint of brass which is successively bent from week to week to force the foot into the desired position, as illustrated by the figures. (Fig. 658, *a*, *b*, and *c*.)

When the resistance to the extreme range of normal motion has been overcome, the first stage in treatment has been completed, but, as has been stated, functional cure cannot be assured until the foot has become consolidated in its new position by a rearrangement of its internal structure and until the muscular balance of the foot—that is, the ability to move it voluntarily in all directions—has been regained. This natural process of reconstruction, although very rapid in infancy, as contrasted with childhood, can hardly be accomplished during the three or more months occupied in correction. Consequently, it is usually necessary to support the foot in the attitude of dorsiflexion and abduction until the child begins to walk. For this purpose a light support of aluminum, hard rubber, or other material may be constructed, or the foot may be held by a strap of adhesive plaster passed under the sole and up the outer border of the leg. The apparatus should be removed, if possible, several times a day to permit massage of the foot and limb and methodical twisting to the limit of movement in every direction.

In many instances the leg is rotated inward on the thigh, and outward rotation may be limited also at the hip. In such cases the methodical manipulation should be employed to stretch the contracted tissues. The muscular action in the weakened group of flexors and abductors may be, with advantage, induced by tickling the sole of the foot or by electrical stimulation and the like. When the child begins to stand, a well-fitting shoe should be provided, and in most instances it is well to assure eversion by making the outer border of the sole somewhat thicker than the inner. If, in walking, the child inverts the foot, an elastic band may be attached to the front of the outer border of the shoe. This is then passed to the outer side of the calf behind the knee and across the front of the thigh and buckled to the centre of the waistband, or, if both feet are affected, to a belt.

The supervision of the postures and the manipulation to assure the complete range of motion must be continued indefinitely if perfect functional cure is desired.

This description represents the ordinary course and outcome of treatment under normal conditions. In certain instances in which it has been delayed or is less effective, or in which the posterior tissues are especially resistant, it may be advisable, after the varus has been corrected, to hasten correction by division of the tendo Achillis. This operation should be performed subcutaneously. The foot having been prepared, the child is anæsthetized and turned upon its face. The foot is forced toward dorsal flexion to make the tendo Achillis tense, and the tenotomy knife is then inserted at a point opposite the extremity of the external malleolus, passed beneath the tendon, turned to bring the cutting edge against it, and it is then divided with a gentle sawing motion and the knife is withdrawn. As a rule, there is no bleeding. When the deformity is corrected after tenotomy, the foot is forced up to complete dorsal flexion. It must be borne in mind that the tendon is but one of the shortened tissues; therefore in overcoming deformity the finger should be passed about the heel to force it actually downward by elongation of the shortened ligaments, and if these are very resistant they may be divided by passing the knife directly inward against the posterior surface of the joint, care being taken to avoid the important parts in the neighborhood of the internal malleolus.

A plaster-of-Paris bandage is then applied in the attitude of overcorrection, and it is allowed to remain for from four to eight weeks, when repair is usually complete.

In applying the plaster, care should be taken that no pressure be brought at the point of division of the tendon, in order that the new material produced by the sheath and from the cut surfaces may not be compressed. Ordinarily this splice in the tendon is, when organized, thicker than the original; and, when the operation is properly performed, there is no danger whatever of non-union or of subsequent disturbance of function. Such results need be feared only in cases of paralytic deformity in which the tissues are feebly nourished and in which the foot is not effectively supported during the process of repair.

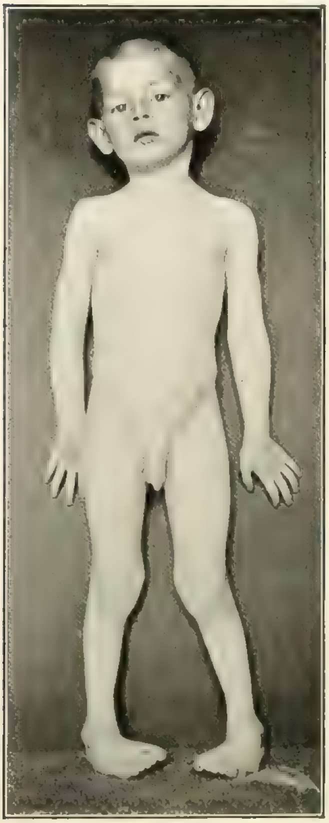


Fig. 659.—Partly Corrected Club-feet, Illustrating Unsuccessful Treatment. In cases of this type forcible correction is indicated.

Thus far the treatment of congenital talipes in infancy has been considered. One now proceeds to the cases in which treatment in infancy has been ineffective and in which deformity has been increased and has become more resistant because of functional use. In the great majority of cases of this type, in children from three to twelve years of age, treatment by braces or by operation has been carried out in a desultory manner, but the principle of complete over-correction of deformity and retention for a sufficient time to permit the necessary transformation of structure has not been appreciated.

In all cases of this class, or, in fact, of any class, one should first attempt to correct or partly to correct the deformity by stretching the contracted tissues before resorting to more radical treatment.

Forcible Manual Correction.—The operation of choice, therefore, is forcible manipulative correction.

The patient being anæsthetized, one attempts to correct the foot at one sitting in the same methodical manner that is employed in gradual correction, namely: to overcome first the inward twist; second, the inversion; and, third, the equinus.

Thus, one seizes the deformed foot in the hand, the fingers grasping the heel, the projection of the palm lying against the convexity of the outer border at the junction of the cuboid with the os calcis. Using this as a fulcrum, the operator forces the forefoot outward with the other hand, alternately stretching and relaxing the tense tissues until they give way, thus rendering it possible to change the concavity of the inner border, without force, to a convexity. Then, in the same manner he overcomes the inversion by repeatedly twisting the foot until the sole may be made to look directly outward.

Finally, the equinus is corrected. If the resistance is great, it is well to divide the tendo Achillis subcutaneously in the manner described. One then hooks his fingers about the heel, the hand lying along the sole; and by repeated applications of force, the bones of the leg being prevented from bending by firmly grasping them with the other hand, the foot is forced upward until the dorsum can be placed in contact with the front of the leg. When the operation is completed, the foot should be limp, all the resistant structures having been so thoroughly stretched that it can be easily placed in the attitude of overcorrection—namely, abduction, eversion, and dorsal flexion—and fixed there by a carefully padded plaster-of-Paris bandage.

It is, of course, apparent that, although the exterior of the foot may be moulded into an approximately normal form, the actual reformation of the internal structures can be accomplished only after many months. The after-treatment, therefore, consists in fixing the foot for several months in the new position. The most efficient and convenient brace for this purpose is the plaster-of-Paris bandage, the sole being made unyielding by the insertion of a thin board foot-plate between the layers of plaster. A properly fitted shoe is applied over the bandage, and the patient is encouraged to walk about, particular care being taken that the proper attitude is assumed in walking. Such functional use hastens the process of transformation and accustoms the patient to the proper use of the limb. At the end of from three to six months the plaster bandage may be replaced by a metal brace. This consists of a steel foot-plate, preferably with a guard along the inner border and an upright passing up the inner side of the leg to the upper third and terminating in a calf-band. This brace should hold the foot in the same attitude as the plaster, and it has the advantage of allowing massage, manipulation, and the voluntary use of the muscles. This voluntary exercise is by far the most important means of cure, but it is possible only when the transforming process has assured the new articulations and when sufficient retraction has taken place in the elongated muscles to permit it. At the end of a year the brace may, as a rule, be discarded, but manipulation and exercises should be continued until normal function is restored.

In the operation of correction that has been described, tenotomies and divisions of contracted fascia may be of advantage in lessening resistance. In many instances it may be advisable to divide the operation into two or more stages, according to the resistance of the tissues and the duration of the de-

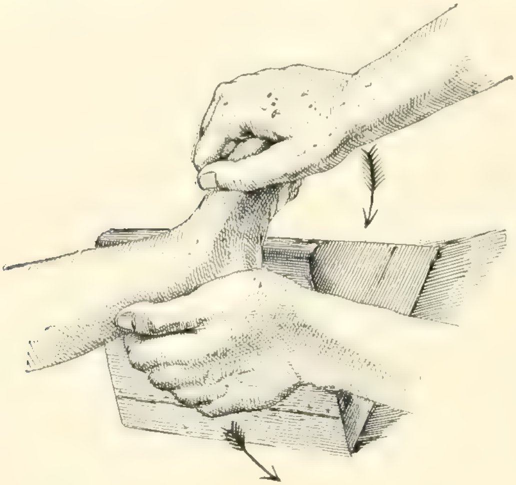


FIG. 660.—Reduction of Varus. (After Lorenz.) By means of a triangular block in the ordinary cases correction may be accomplished by the hands alone, as described in the text.

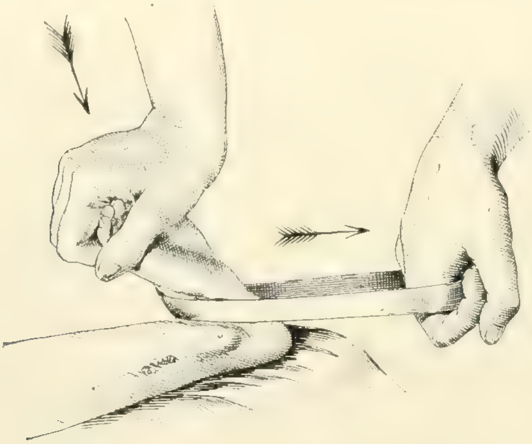


FIG. 661.—Reduction of Cavus. (After Lorenz.)

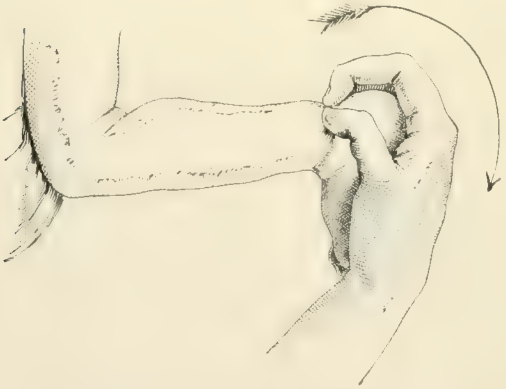


FIG. 662.—Reduction of Equinus. (After Lorenz.)

formity. When, for example, it is feared that further stretching would endanger the circulation of the skin, the foot is allowed to relax somewhat and, after it has been carefully padded to prevent pressure, a plaster bandage is applied. After an interval of one or more weeks the process of correction is completed.

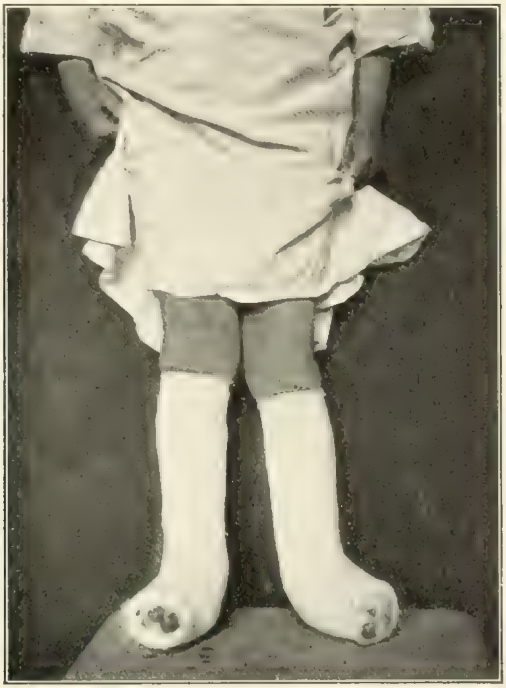


FIG. 663.—Illustrating Treatment by Forcible Manipulation, and the attitude in which the feet are fixed by plaster bandages so that functional use may complete the correction.

Manipulative correction, without the aid of instruments, has the advantage of safety, since pressure of the hands is far less likely than wrenches to injure the tissues, but occasionally in very resistant cases, particularly those in which the plantar tissues are contracted, the Thomas wrench may be employed with advantage. This, a modification of the ordinary monkey wrench, is placed on the inner border of the foot, which is firmly grasped by the jaws, and it is then twisted to the desired position. If the pressure is not prolonged, the vitality of the tissues is not impaired.

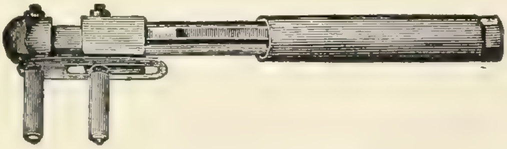


FIG. 664.—The Thomas Wrench.

Simple forcible correction by itself, or as a preliminary treatment, has the great advantage that it affects all the tissues, as contrasted with cutting operations, in which the correction is localized at the point of incision.

Phelps' Operation by Open Incision.—In cases of the resistant type, especially in older subjects, more radical procedures may be required to correct the deformity. Of these the most conservative is forcible correction after complete division of the contracted parts according to the method advocated by Phelps. The foot having been properly prepared, one reverses the usual method and attempts to correct the equinus first by subcutaneous tenotomy and by force. The foot is then turned upon the outer side and an incision about two inches in length is made directly downward over the astragalo-navicular articulation, the incision beginning at a point just below the level of the internal malleolus and about three-quarters of an inch in front of it. The articulation is opened by a complete division of the ligaments, and the foot is then twisted outward and upward, opening a wide, deep, wedge-shaped wound; all tissues that resist this correction, including, if necessary, the tendons of the tibialis anticus and tibialis posticus, the plantar fascia, vessels, nerves, and the like, being divided as they appear. Bleeding points are sutured, the wound is covered with protective tissue and gauze, and a light plaster-of-Paris bandage is applied in the position of overcorrection. In ordinary cases the original bandage remains for from two to three weeks. When it is changed, the deep wound is practically filled with granulation tissue,

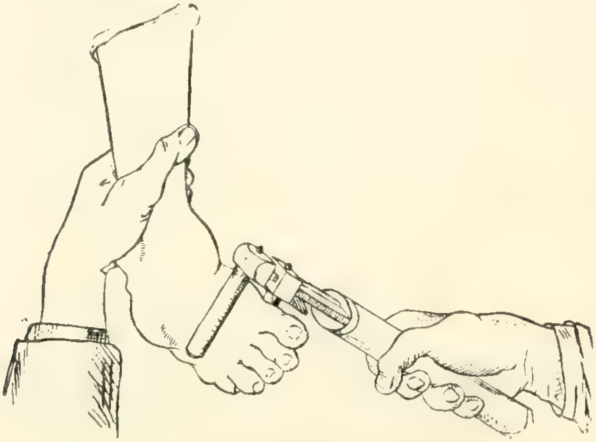


Fig. 665.—The Thomas Wrench Applied to a Case of Talipes Equino-Varus.

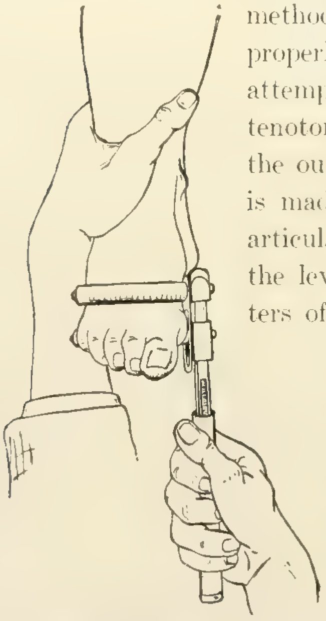


Fig. 666.—The Deformity Partially Corrected by the Wrench.

and at the end of a month or more it is completely closed. The after-treatment by fixation and protection is the same that has been described. The particular advantage of the operation is that it permits complete and rapid correction of the most important part of the deformity, namely, the varus, at a single sitting. This method, however, is not regarded as highly as it was formerly.

Astragalectomy.—In certain instances, particularly of the adult type of deformity, the displaced and distorted astragalus prevents replacement, the bone articulating with the malleoli only at its posterior aspect. In these cases the removal is advisable if, when the varus deformity has been entirely corrected by force or by open incision, it is impossible to force the foot up to a right angle with the leg. In other words, astragalectomy should always be a secondary operation.

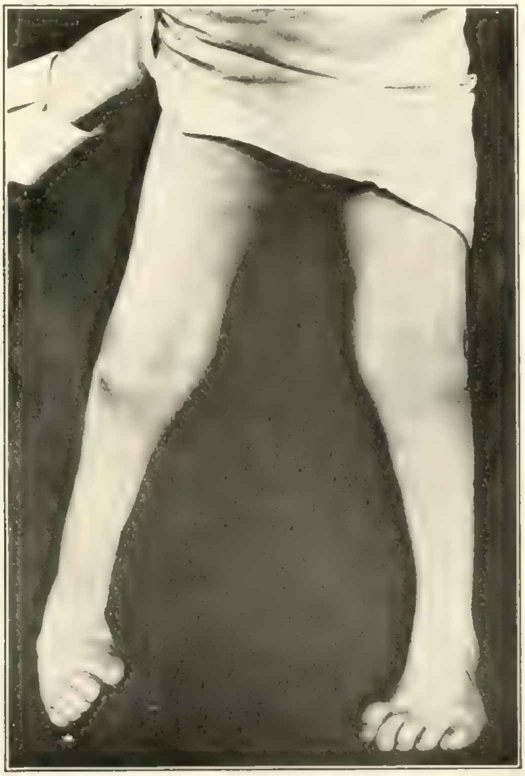


FIG. 667.—Resistant Club-foot in Childhood. A type in which the Phelps operation may be indicated.

In cases of this character the astragalus is so far displaced that it may be easily removed by a curved incision extending from just below and behind the external malleolus, forward and inward over its projecting body to the outer extremity of its head. The ligaments attached to the malleolus are divided, the interosseous ligament is severed with a thin knife passed between the bones, and finally all the tissues that connect the head of the astragalus with the navicular. The foot is then forcibly adducted, exposing the head of the astragalus, which is seized with bone-forceps or with the fingers and removed, sufficient force being exercised to tear the tissues on the inner and posterior surface that are not accessible to the knife or scissors. The space thus gained compensates for the short posterior tissues, and the foot is fixed, with or without drainage, by means of a plaster bandage in the overcorrected attitude.

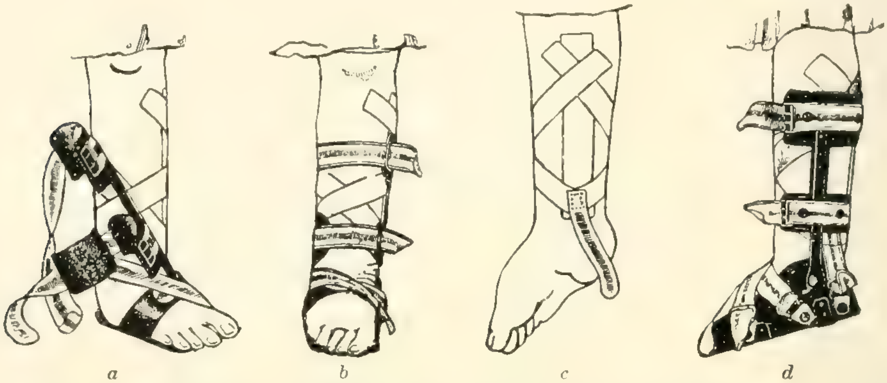


Fig. 668.—The Taylor Club-foot Brace, as Used to Correct the Deformed Foot by Leverage. *a*, Adjusted to the foot; *b*, correction of varus when the upright is adjusted to the leg; *c*, adhesive plaster attached to the brace to hold it in position; *d*, the brace adjusted.

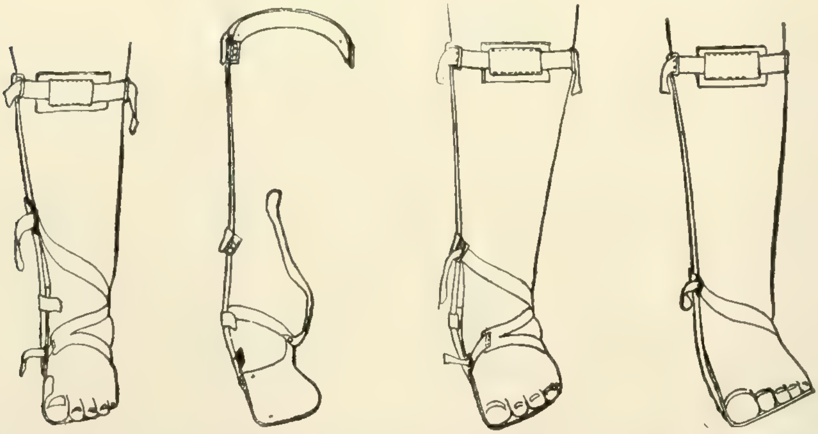


Fig. 669.—Judson's Modification of the Taylor Brace, Consisting of a light Steel Foot-piece Fixed to an Upright. This may be bent to adjust it to the foot in the attitude of overcorrection.

Astragalectomy, by relaxing the tissues and removing all obstruction to motion, permits the extreme degree of dorsal flexion and relieves the stiffness at the ankle that is so common in cases of this type treated by other methods.

Cuneiform Osteotomy.—In cases of the adult type in which the deformity is extreme, it is sometimes necessary, in order to make the foot symmetrical, even after astragalectomy, to remove a wedge from the convexity of the outer and upper border of the foot. In this is usually included the anterior extremity of the os calcis. The deformity having been corrected, it is well to press one or more sutures through the adjoining bones to assure ankylosis. A plaster bandage is then applied.

In all operations of this class the use of the Esmarch bandage is of advantage in that it enables one to perform the operation more quickly and accurately. It may be removed to allow the suture of bleeding points, but this is hardly necessary, as the correction of the deformity, which insures pressure, and the elevation of the limb check the hemorrhage from the bones. If the operations are conducted aseptically, there is practically no danger. Drainage may be used or not, according to the indications.

As soon as the sensitiveness has subsided and the wound has closed, a light plaster bandage is applied and the patient is encouraged to walk. If the deformity has been overcorrected, there is but little tendency for the foot to relapse, and with ordinary care as to corrective manipulation in the after-treatment braces are not required.

In cases of this class, the object of treatment is to make the foot symmetrical. Complete restoration of normal function, as is possible in childhood, is, of course, out of the question; in fact, it is because of this persistent stiffness and because of the cessation of growth that the danger of recurrence of deformity is comparatively slight.

It may be noted that in this outline of treatment of club-foot under proper conditions, functional cure rather than mere correction of deformity is the aim in view. Correction of deformity, being the essential preliminary to transformation of the tissues, should be assured as quickly and as completely as possible. This is opposed to the former methods, in which gradual and partial correction by braces, a process often occupying many years, was more generally employed. There are, of course, many cases in which brace treatment with its accessories, even when applied in later childhood, is eventually successful. It seems far preferable, however, in this class of cases to restrict the function of the brace to the simple support after the deformity has been corrected.

Other Forms of Talipes.—The other forms of congenital talipes, varus, valgus, and calcaneus, are relatively insignificant in number and in importance. These deformities are also usually far less resistant than ordinary club-foot. In many instances the deformity may be overcome by systematic manipulation by the nurse or parent. If the deformity is more obstinate, gradual correction with fixation in the manner described may be employed.

Complications of Congenital Talipes.—As has been stated, in many instances the foot is smaller than normal or thicker and broader in proportion to its length. These imperfections usually become less marked under treatment and with growth. In some instances there are constricting furrows or bands, apparently due to amniotic adhesions, about the foot or limb, but these rarely require treatment.

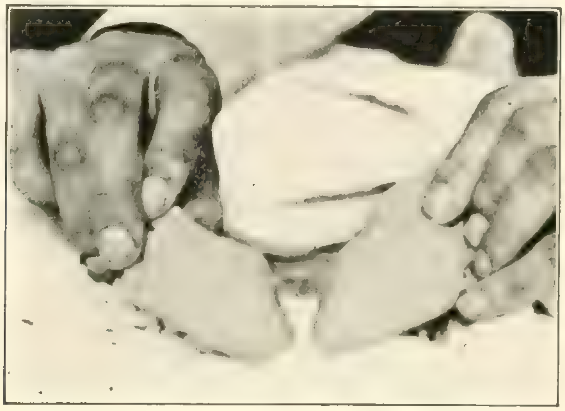


FIG. 670.—Congenital Talipes Valgus—"Flat-foot."

Club-foot sometimes accompanies spina bifida, in which case actual paralysis of motion and sensation may in certain cases be present.

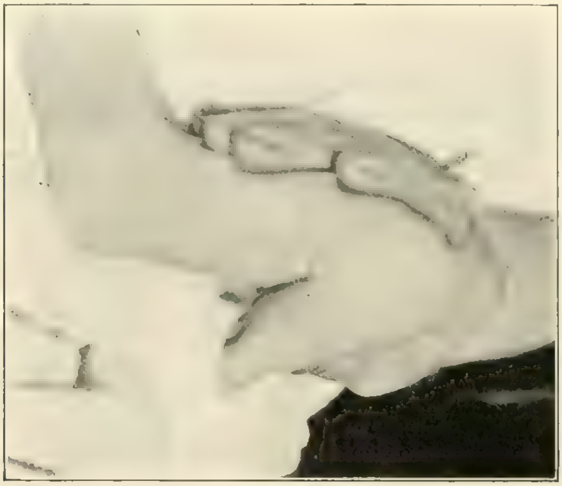


FIG. 671.—Congenital Talipes Calcaneus.

Other forms of congenital paralysis, except spastic hemiplegia or paraplegia due to prenatal disease or to injury at birth, are uncommon. In certain instances the limb may be shorter or toes may be lacking, or the foot may be fissured or otherwise malformed. Of this type the most important cases are those in which the bones of the leg are absent or rudimentary.

If, for example, the fibula is absent, the foot is usually in an attitude of equino-valgus and in many instances the two outer toes, with their corresponding metatarsal bones, are lacking. There is often a sharp anterior angular bending of the tibia at about its centre, with what resembles a scar at the point of convexity. This was supposed at one time to be a so-called intra-uterine fracture, but it is now thought to be a deformity induced by the lessened resistance of the limb.

If the tibia is absent or is rudimentary, the attitude is often that of equino-varus, and the great toe or the first two toes may be lacking. In this class of cases the entire limb is usually shortened, the shortening being most marked in the leg, but also apparent in the thigh. This is more marked when the tibia is absent than the fibula, and the disparity increases with the growth of the child.

The indications for immediate treatment are to overcome the deformity of the limb and foot and to support it with braces. Various operative procedures have been employed, but the final results are not particularly encouraging. If the growth of the leg is very much impaired, the treatment of selection is to fit the extremity for a proper artificial limb.

The ordinary forms of talipes are not, as a rule, accompanied by other deformities, but those cases which are accompanied by deficiency of bones or other tissues are more often complicated by malformations of other parts.

Acquired Talipes.—In the description of congenital talipes it was stated that in the great majority of cases the cure of deformity implied the cure of disability.

In acquired talipes, on the other hand, the cause of deformity is almost always paralysis, and, although the deformity is far more easily overcome than when it is of congenital origin, a cure is out of the question if the original cause persists.

The nature of the paralysis in about eighty-three per cent of the cases is anterior poliomyelitis. In eleven or twelve per cent it is due to cerebral hemiplegia or paraplegia. A small percentage of the cases may be accounted for by neuritis or other localized paralysis, and about five per cent are the direct or indirect effect of injury, such as fracture or scar contraction, or of local disease in which a portion of the bone has been destroyed.

Congenital talipes is far more common in males than in females, while in acquired talipes there is but a slight difference in favor of the former sex. In acquired talipes the affection is more often limited to one foot, and, as appears in the table of statistics, the equino-varus deformity is relatively far less common than are the congenital cases.

RELATIVE FREQUENCY OF THE DIFFERENT FORMS OF ACQUIRED TALIPES, TOGETHER WITH THE ETIOLOGY.

	Spinal.	Cerebral.		Other forms of Paralysis.	Traumatic.	Total.	Per cent.
	Anterior Poliomyelitis.	Hemiplegia.	Paraplegia.				
Equino-varus	479	28	35	4	29	575	32.5
Equinus	321	66	46	3	26	462	26.1
Calcaneus	219	3	1	0	1	224	12.6
Valgus	134	4	7	1	27	173	9.7
Equino-valgus	114	0	5	0	3	122	6.9
Calcaneo-valgus	76	0	0	0	2	78	4.4
Varus	41	2	1	0	5	49	2.7
Calcaneo-cavus	12	0	0	0	0	12	
Equino-cavus	22	0	0	0	2	24	1.3
Calcaneo-varus	11	0	0	0	0	11	
Cavus	35	1	0	0	0	36	2.0
Varo-cavus	1	1	0	0	0	2	
	1,465	105	95	8	95	1,768	
Deformity different on each side	......	......	......	......	......	50	

Anterior poliomyelitis .... 1,465 = 82.8 per cent
Cerebral .... 200 = 11.3 "
Traumatic .... 95 = 5.3 "

COMPARATIVE FREQUENCY OF THE DIFFERENT FORMS OF TALIPES, CONGENITAL AND ACQUIRED.

	Congenital.	Acquired.
Equino-varus	77.0 per cent	32.5 per cent
Valgus	7.4 "	9.7 "
Varus	5.1 "	2.7 "
Calcaneo-valgus	3.1 "	4.4 "
Equinus	2.4 "	26.1 "
Calcaneus	1.7 "	12.6 "

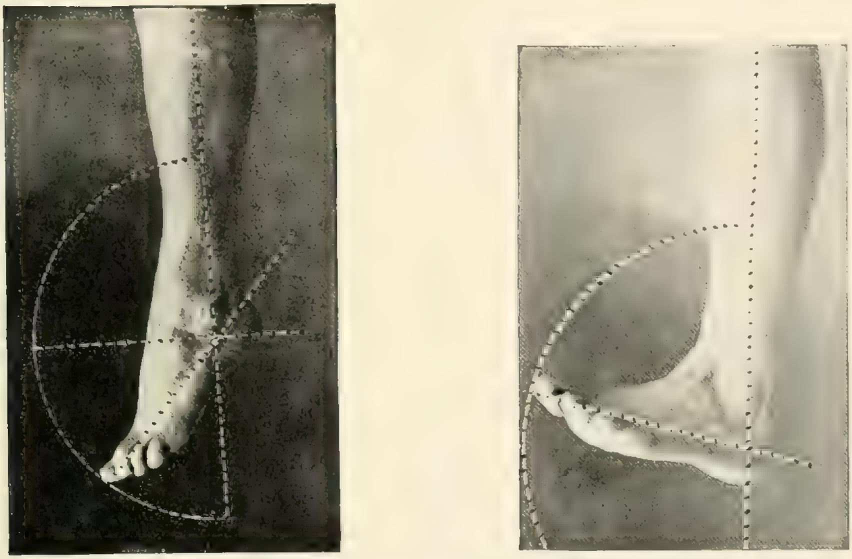
The development of acquired talipes due to anterior poliomyelitis is somewhat as follows:

There is primarily the paralysis, usually more extensive than that which eventually persists, and generally accompanied at its onset by more or less constitutional disturbance.

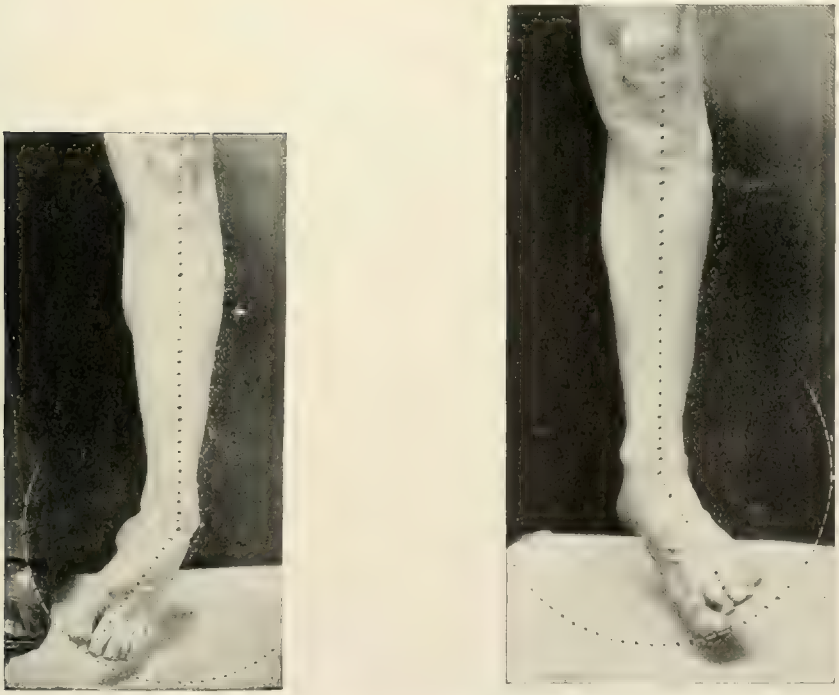
This is followed, after several weeks or months, by a stage of recovery which lasts for six months or longer, although in cases properly treated the gain in functional ability may continue almost indefinitely. This may be accounted for in part by compensatory hypertrophy of the muscles or portions of muscles that are still active, and in part, it may be, by similar adaptation in the spinal cord.

The proper treatment of anterior poliomyelitis implies prevention of deformity, since, in a large proportion of cases, deformity increases the disability due to paralysis.

In the development of acquired talipes there are three important factors:



FIGS. 672 and 673.—Normal Range of Motion at the Ankle Joint.



FIGS. 674 and 675.—Normal Range of Motion at the Medio-tarsal and Astragalo-calcaneoid Joints.

the force of gravity, the action of the unbalanced muscles, and finally functional use of the weakened or deformed member. The influence of the force of gravity is particularly important because the anterior muscles of the leg are usually involved in any form of paralysis; consequently the foot sinks into an attitude of equinus which persists. Meanwhile the posterior muscles contract in adaptation to the persistent attitude and after a time become actually shortened. It is this adaptive retraction, even more than active muscular contraction, that determines the original deformity. In most instances muscular contraction and gravity are combined to induce deformity, but if the posterior leg group is paralyzed, the anterior muscles retaining their power, the two are then opposed, and deformity does not appear until the part is used in walking. Thus, although equinus usually appears, even though all the muscles are paralyzed, the development is much more rapid when the posterior muscles are unaffected.

Functional use when the weight of the body falls habitually to one or the other side of the centre of the foot exaggerates the distortion; meanwhile there is a natural adaptation of the tissues and of the remaining muscular power to the habitual posture and use, which adapts the internal structure to the distortion. Thus, certain cases of paralytic deformity of long standing may be almost as difficult to correct as the congenital form.

Paralytic talipes is in most instances an unnecessary deformity. In its prevention the following points are of importance:—

The paralyzed part should not be permitted to remain in the attitude of deformity, but should be regularly rubbed—a treatment that is almost never neglected,—and passive motion should be pushed to the limit of normal action at each joint several times during the day, to prevent the muscular retraction that has been mentioned. It is of advantage, also, to support the part in the normal position by some form of simple apparatus during the stage of paralysis; and if, as is true in most instances, recovery is incomplete, a brace must be used to hold it in proper position when function is resumed. It is because of the neglect of such preventive treatment that paralytic talipes is common.

The character of deformity is dependent upon the distribution of the paralysis. If, therefore, one is familiar with the function of the muscles he may predict accurately the form of distortion that must follow. If all the muscles on the front of the leg are paralyzed, then the foot will sink downward into equinus. If the tibialis anticus muscle, the most powerful of the dorsal flexors and adductors, is lost, equino-valgus will follow. Varus results from paralysis of one or more of the peronei; calcaneus, if the power of the calf muscle is lost; and between the well-marked deformities one finds every grade of weakness and distortion, depending on the damage that has been sustained and upon the quality of the protection that has been provided.

Acquired Talipes Equinus.—Talipes equinus is by far the most common of the acquired deformities of the foot. The slighter forms have already been described under the title of the "Contracted Foot." Even marked deformity may follow such simple causes as long confinement to bed, from one or another cause, the position of extension being favored by the weight of the bedclothes.

There are several degrees of equinus, from slight limitation of dorsal flexion to complete extension of the foot upon the limb, the toes even being fixed in flexion. In the ordinary case the weight is borne principally on the anterior part of the foot, which is somewhat broadened. The toes are contracted and the longitudinal arch is increased in depth. If the limb is shorter than its fellow, for which the extended foot serves as compensation, there is, as a rule, but little discomfort. In other instances, however, the limitation of dorsal flexion makes the gait awkward and there is discomfort whenever tension falls on the shortened tissues. There is often pain about the contracted plantar fascia and at the metatarsal arch.

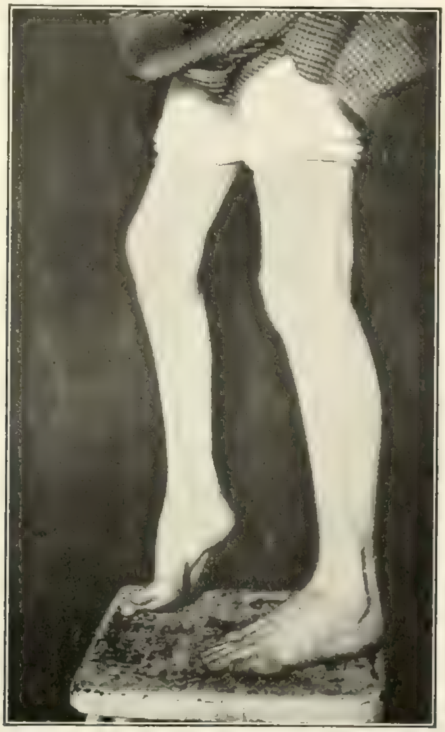


Fig. 676.—Talipes Equinus of Paralytic Origin, with Slight Secondary Varus.

Treatment.—In most instances the correction of the deformity is indicated even though the limb is short. In mild cases this may be overcome by mechanical means or by manipulation under anæsthesia; but if the deformity is fixed, division of the contracted parts is indicated. The patient being anæsthetized, one first endeavors to straighten the cavus deformity of the foot. A tenotome is inserted in the skin at the deepest part of the arch, and is passed over the central tendon of the plantar fascia, which is then divided with a sawing motion. If other bands appear they are also divided. A Thomas wrench is then applied and the cavus is, as far as it may be, overcome by the sudden application of force, supplemented, of course, by forcible manipulation. Afterward the tendo Achillis is divided subcutaneously at a point about an inch above its insertion. The foot is then forced upward to the normal limit of dorsal flexion and a plaster bandage is applied, the foot being protected adequately with cotton, the thickness of the padding varying with the degree of force used in correction. Care must be taken that no pressure shall be exerted on the interval between the severed ends of the tendon, as it would interfere with the fusion of the plastic material of which the splice is constructed. Usually, within a few days the patient may walk about, the sole part of the bandage having been strengthened, if necessary, by the addition of a thin board. Walking during the stage of repair aids in the complete correction of deformity and hastens the healing process in the tendon. If one prefers, a plastic operation may be made on the tendon and the ends united by suture, but, in my experience, there is little, if anything, to be gained by the more complicated procedure, unless the deformity is so extreme and resistant that the open incision is required to enable one to divide other contracted parts. The operation is, of course, simply for the correction of deformity, but in many instances the overcorrection of the malposition is followed by a surprising gain in the ability of the muscles apparently paralyzed, so that not infrequently a practical cure is attained. If, however, the anterior muscles are paralyzed, a brace to support the foot at a right angle with the limb and thus to prevent deformity is essential, at least in childhood.

This brace should be of the simplest description, consisting of a steel sole-plate of sufficient size, when covered with a leather sole, to support the foot, and attached to an upright passing up the inner or the outer side of the leg according to the lateral inclination of the foot—the outer side if toward varus, the inner if toward valgus—in order to avoid pressure on the ankle. The apparatus terminates in a calf-band and strap. (Fig. 679.) If there is no joint at the ankle, the brace is more durable. If a joint is used it must be provided with a catch to prevent foot-drop.

Adult patients often dispense with braces, and, if the limb is several inches shorter than its fellow, a so-called extension shoe fitted to the foot in the equinus attitude may be employed.

The treatment of equino-varus and equino-valgus deformity is conducted on the same principle, namely, thoroughly to overcorrect the distortion and to hold the foot by means of a plaster bandage in this attitude until the parts have become accommodated to the new position. Afterward a brace, of the nature of that described, is to be used to support the foot. If varus deformity is present the foot-plate should have an elevation along its inner border corresponding to the thickness of the foot, against which the foot may be strapped. If, on the other hand, the inclination is toward valgus, the elevation may be placed on the outer side. The leg upright passes up the outer side of the leg, and the attitude may be still further assured by a wide leather band passing from the sole-plate over the arch and inner side of the ankle, and buckled about

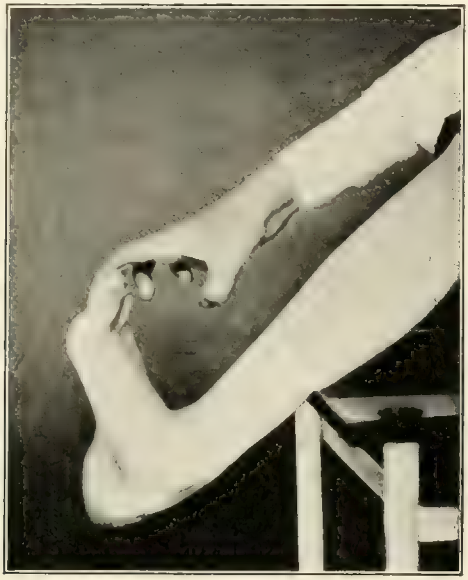


Fig.677.—Paralytic Talipes Calcaneus, in which the Secondary Changes are Slight.

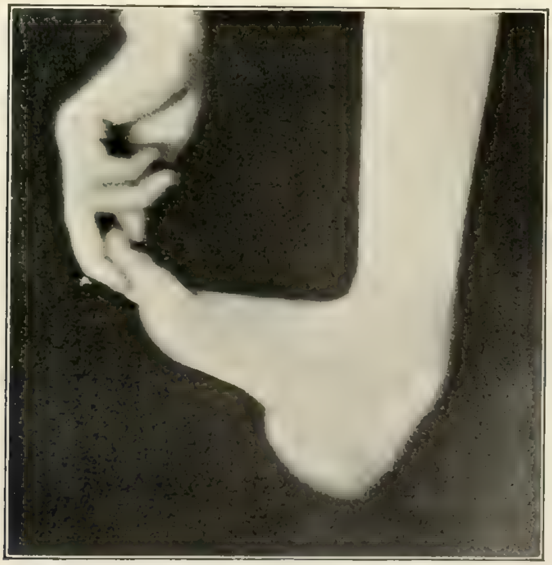


Fig. 678.—Acquired Talipes Calcaneus, Showing the Hypertrophy of the Heel and the Secondary Cavus.

the upright. A shoe is then fitted to the brace, its inner or outer border thickened to correspond to the inclination of the sole-plate, according as the deformity is either valgus or varus.

Other Operative Procedures; Tendon Transplantation and Arthrodesis.—If the deformity is equino-valgus, caused, as is often the case, by paralysis of the tibialis anticus muscle, the most effective treatment is the obliteration of the medio-tarsal joint with the aim of preventing lateral deformity, combined with the transplantation of the extensor proprius hallucis tendon to a point where it may act as a supinator of the foot rather than as a toe muscle. (Consult also Dr. Stewart's article in Vol. II.

In all operations of this class the Esmarch bandage is of advantage. As a preliminary measure, restriction to normal movement is overcome by forcible manipulation combined usually with tenotomy of the tendo Achillis. An incision, beginning above the ankle joint and curving slightly inward to a point just in front of the astragalo-navicular articulation, should then be made in the line of the tibialis anticus tendon. This joint is opened, and a narrow wedge of bone is removed from the adjoining bones. The tendon of the proprius hallucis is drawn upward and divided at a point about an inch from its insertion. A hole is then made through the inner third of the navicular by means of a sharp trocar and cannula, and the tendon is drawn through. The foot is then forced into an attitude of calcaneo-varus, the wedged-shaped opening on the inner side being thus made to close, and in this position the two bones are united with a strong silk ligature. The hallucis tendon is then drawn down until it is tense, and it is sewed upon itself with silk.

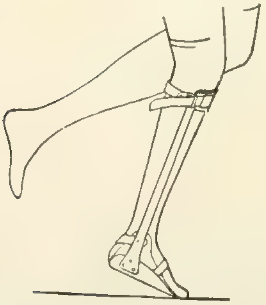


Fig. 679.—Judson's Brace Applied for Talipes Calcaneus.

In most instances the tendon of the paralyzed tibialis is cut or shortened or overlapped in order to serve as an aid in retaining the foot in proper position. The wound is then closed with two layers of fine catgut, and a plaster-of-Paris bandage is applied, which should be worn preferably for several months, and until the parts have become thoroughly consolidated in the new position.

If care is exercised that the range of dorsal flexion shall not become limited, braces may usually be dispensed with. Thickening the inner border of the shoe, and the use of a flat-foot brace are, of course, indicated if any tendency toward valgus persists.

On the other hand, in cases of equino-varus, due to paralysis of one or more of the abductor group, after the preliminary stretching that has been described, an incision beginning about two inches above the joint and curving downward and outward to the calcaneo-cuboid junction, is made on the front of the ankle. A thin wedge of bone, including the outer half of the astragalo-navicular articulation and the calcaneo-cuboid junction, is made of such dimensions that, when the gap is closed, the foot will be held in moderate varus. The hallucis tendon is next separated near the metatarso-phalangeal joint by means of an incision at this point, is carried across the foot beneath the other tendons, and is drawn through a hole bored in the cuboid bone or attached securely to the periosteum. If, as in certain instances, the paralysis of the abductors is so extensive that the power of the tibialis anticus muscle is evidently too great, or if the muscle alone remains active, its tendon is split to include the muscular belly, and the outer half is carried across the foot to be attached to the same point. In most instances the insertion into the bone must be made by elongating the splice somewhat by a cord of strong silk, the tendon itself being securely sewed to the periosteum in the neighborhood.

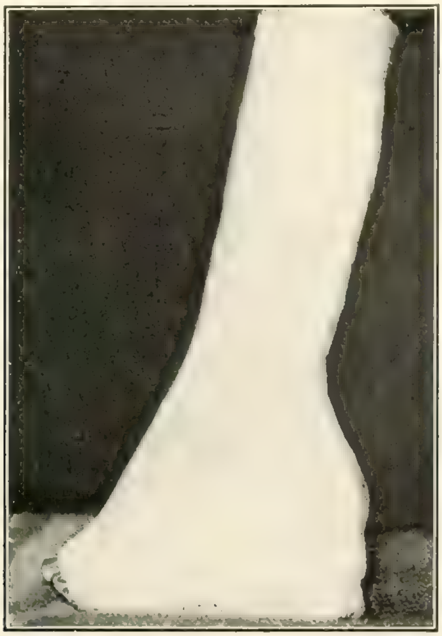


FIG. 680.—The Plaster Bandage with Cork Sole Used in the same Case (Fig. 678) to Maintain the Foot in the Proper Attitude during the Period of Repair. (Original.)

Arthrodesis.—The principal disability incidental to paralysis of the anterior leg group of muscles is due to a dropping of the foot, so that an exaggerated lifting of the knee is necessary for locomotion. In certain cases, particularly in those in which the paralysis is complete, the operation of arthrodesis may be indicated, the object being to fix the foot at a right angle with the leg. For this purpose, at least in childhood, the obliteration of the medio-tarsal joint, as well as the ankle joint, is necessary.

An Esmarch bandage having been applied, an incision, beginning an inch above the centre of the ankle joint, is extended downward on the dorsum of the foot to about the middle of the tarsus. The tissues are retracted and the foot is plantar-flexed to the full limit, exposing the greater part of the astragalus. From the top and sides of the bone the cartilage is removed with a sharp narrow knife, and sufficient space is thus gained to permit the removal of the greater part of the cartilage from the malleoli and from the upper surface of the joint. A thin wedge of bone, including the astragalo-navicular and the upper part of the calcaneo-cuboid articulation, is cut with a thin chisel. Then the foot is pushed upward against the resistance of the tendo Achillis and the cut surfaces are forced into apposition. The wound is then closed and a plaster-of-Paris bandage is applied. The limb should be kept elevated for twenty-four hours to prevent oozing. As soon as the sensitiveness has subsided, the patient is encouraged to use the foot. Protection, either by a plaster bandage or by a suitable brace, should be assured for a period of six months or longer, in order to permit consolidation.

This operation is of particular value in cases of extensive paralysis of the limb, for, if deformity of the foot can be prevented, the appliance may be so constructed as to be less burdensome and more comfortable.

Acquired Talipes Calcaneus.—Calcaneus deformity follows paralysis or loss of function of the calf muscle. As a result the os calcis, deprived of its support, tends to assume a vertical rather than a horizontal direction; thus the projection of the heel is lost, the foot is shortened, and the arch is increased in depth.

Calcaneus is usually a paralytic deformity. If the calf muscle alone is paralyzed, the other muscles offset the action of the dorsiflexors, but, as at the same time they draw upon the forefoot, they induce or exaggerate the secondary cavus. If the adductors or abductors on the front or back are paralyzed in addition, the deformity becomes calcaneus varus or valgus.

The typical deformity caused by the loss of the calf muscles does not appear until the part is subjected to functional use. As the propelling power is lost, the patient is, as it were, hamstrung, and he stamps about on the insecure heel with a peculiarly awkward and characteristic gait. The distance from the bearing surface of the sole to the malleoli is considerably increased. The area of the heel, which alone supports weight, is greatly exaggerated, while the growth of the remainder of the foot, which serves merely as an appendage, is markedly checked. Thus, in well-developed cases the disproportion in the size of the feet, due in great part to loss of function, is more noticeable than in any other form of acquired talipes.

One may recognize, then, two types of talipes calcaneus: One—as, for example, soon after the onset of the paralysis—similar to the congenital form, in which there is but little deformity except that due to the limitation of plantar flexion (simple calcaneus—Fig. 677); and a second class in which the secondary deformity has been induced by functional use (calcaneo-cavus—Fig. 678).

Treatment.—The development of the characteristic deformity is explained by the failure to protect the weakened member. Preventive brace treatment is, therefore, very important. Such a brace is practically an upright bar with a calf band and well-padded strap to pass across the upper third of the tibia, together with a strong steel foot-plate, long enough to reach to the metatarso-phalangeal joints, firmly riveted to the upright at a downward inclination so that the foot may be held in slight equinus. If the foot is inclined to one or the other side an internal flange on the foot-plate, as described under Equinus, is of advantage. The brace is placed inside the shoe, the heel of which is accommodated to the equinus; straps may be used, if necessary, to hold the foot firmly against the brace. This brace supplies the resistance necessary in walking, and with its aid the disability may be hardly noticeable. (Fig. 679.)

Correction of Deformity.—The correction of the secondary cavus is difficult because of the absence of resistance in the posterior tissues. The ordinary operation is to divide the plantar fascia with a tenotome, and then forcibly to reduce the deformity, as far as may be, with a wrench or osteoclast, after which a plaster-of-Paris bandage is applied.

Tendon Shortening.—If, as in the milder cases, the deformity is pure calcaneus, and if a certain degree of power remains in the calf muscle, shortening the tendo Achillis may be of value. A straight incision is made over the tendon. This is freed, divided in a diagonal direction, overlapped to a degree sufficient to hold the foot in moderate equinus, and sewed firmly with silk. The wound is closed and a plaster-of-Paris bandage is applied. This, or a protective brace, must be worn indefinitely, provided the muscle does not gain sufficiently to perform its function. Even if but little power remains it may be sufficient to hold the os calcis in position and thus prevent the secondary cavus.

Tendon Transplantation.—In cases of the milder type, and for the purpose of providing sufficient power to prevent the development of deformity, tendon transplantation may be employed. If, for example, the foot is inclined toward varus one may lessen the tendency toward adduction by transplanting the tibialis posticus tendon; or, if it is inclined toward valgus, one or both of the peroneal tendons may be used. If no lateral deformity is present, one or more of the tendons from both sides may be transplanted.

The operation is essentially simple. A long incision is made over or on one or the other side of the tendo Achillis; the tendons behind the inner or outer malleolus are thoroughly freed from their sheaths, divided and passed through the periosteal insertion of the tendo Achillis, drawn to the proper degree of tension, and sewed firmly with silk, or preferably a hole may be made in the os calcis below the insertion, and through this hole the tendon may be passed. The tendo Achillis is then shortened and the wound is closed. A protective brace must be worn indefinitely.

Arthrodesis.—When the movement of a joint cannot be controlled, arthrodesis may be indicated. This operation is of particular value when the secondary deformity of the foot is slight. The ankle joint may be opened from the front, back, or side. Opening it from the back has the advantage that it permits shortening of the tendo Achillis. The most thorough operation is the lateral. A curved incision is made beneath the external malleolus and, the ligaments having been divided, the foot is forcibly dislocated inward, the joint thus being thoroughly exposed. The cartilage having been removed, the foot is restored to its normal position and the wound is closed.

After the operation of arthrodesis, the foot should be supported for a long time, for in childhood the bones are in great part cartilaginous, and firm ankylosis is very difficult to attain, at least firm enough to withstand the adverse leverage that falls upon the foot.

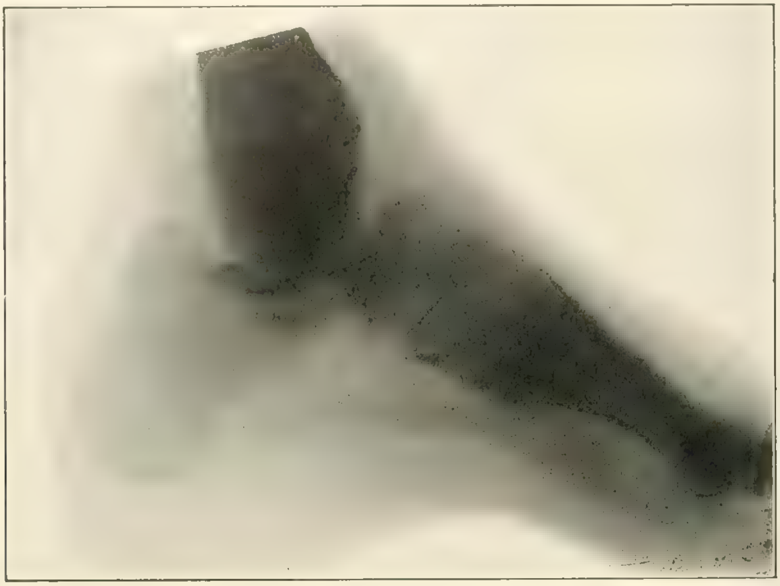


Fig. 681.—An x-ray Picture of the Case represented in Fig. 678, showing the Relations of the Bones of the Leg to those of the Tarsus After the Operation, also the Contour of the Foot. (See Fig. 682.) (Original.)

Operations for Advanced Deformity; The Author's Operation.—If the secondary deformity of cavus is well marked, if, in other words, the os calcis has assumed the vertical position, the deformity being of the character of the Chinese foot, and particularly if it is inclined laterally, a more radical operation is indicated.

The first step is the removal of the astragalus because the uncontrolled movement above and below it is the principal cause of the insecurity of the gait. A long curved incision is made from a point just anterior to the tendo Achillis, below the outer malleolus, to the front of the joint. The sheaths of the peronei tendons are exposed, and the two tendons, having been thoroughly freed from their sheaths, are divided as far forward as possible and are retracted. The lateral ligaments are then severed, and the foot is forcibly displaced inward; when the attachments about the head and body of the astragalus are cut it may be easily removed. A thin section of bone is removed from the outer aspect of the adjoining os calcis and cuboid bones, and on the inner side the calcaneo-navicular ligament is separated from the navicular to provide space for the internal malleolus. The cartilage is then removed from the malleoli, and they are reshaped, if necessary, to adjust them to their new positions. The peronei tendons, provided the muscles are active, are attached to the insertion of the tendo Achillis or passed through a hole bored in the os calcis, and are made fast with strong sutures. This part of the operation is of particular value when valgus deformity is present. The entire foot is then displaced backward, so that the denuded malleoli overlap—on the outer side the calcaneo-cuboid junction, and on the inner the posterior border of the navicular. This displacement restores the projection of the heel and increases the stability of the foot, by preventing lateral distortion and by lessening the adverse leverage. The wound is then closed without drainage, and the foot is fixed in moderate equinus by a plaster bandage. This or a brace should be worn for many months. By this operation the symmetry of the foot is restored and its stability is so increased that in many instances apparatus may be dispensed with. If the anterior muscles are of undiminished power, it may be advisable to lessen their strength. For example, the tendon of the tibialis anticus may be transplanted to the os calcis just in front of the malleolus, so that it would be comparatively inefficient as a dorsal flexor.

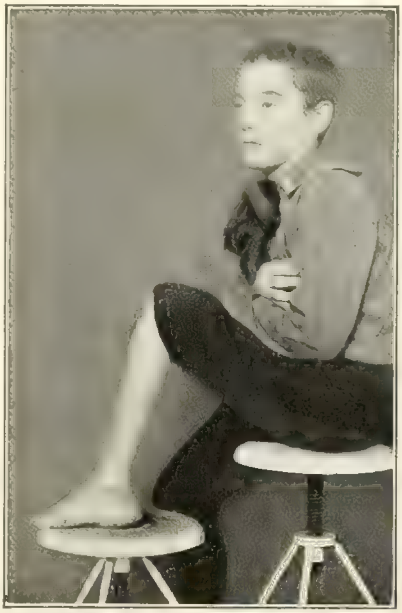


Fig. 682.—Illustrating the Appearance of the Foot after the Author's Operation for Talipes Calcaneo-valgus.

It may be noted that tendon transplantation is a subordinate part of the operation, for it must be apparent that no combination of weak muscles can replace the calf muscle, which is at least six times as powerful as all the others combined. The removal of the cartilage probably adds somewhat to the stability of the foot after this operation, but it does not cause ankylosis.

When the brace is discarded, a strong shoe provided with a wedge of cork as an inner sole will support the foot in moderate equinus and compensate somewhat for the shortened limb, which, in cases of this class, is usually considerable.

Talipes Valgus.—In rare instances the tibialis posticus muscle is alone paralyzed, and, as a result, the foot as a whole assumes the position of valgus. In such cases the principal antagonist, the peroneus brevis, may be utilized to replace it.

This will necessitate several incisions: one about an inch above the posterior aspect of the external malleolus, to isolate the muscle; a second at the insertion of the tendon at the cuboid bone in order to divide it. The tendon is then drawn backward and, thoroughly separated from its sheath, is passed beneath the tendo Achillis. A third incision behind the internal malleolus exposes the tibialis posticus tendon to which the grafted tendon is securely sewed with silk at sufficient tension to hold the foot in slight adduction. It is advisable to elongate the peroneus tendon with a strong band of silk and to attach it to the internal border of the navicular also. This will necessitate a fourth opening.

A less complicated but less satisfactory procedure is to separate a narrow section from the internal border of the tendo Achillis, including a portion of the muscle, and to attach this in the same manner as described. It is less satisfactory, because it does not remove at the same time an opposing force.

The wounds are then closed and the foot is fixed in an attitude of slight varus for several months. In many instances a flat-foot brace may be necessary to prevent recurrence of deformity.

TUBERCULOUS DISEASE OF THE SPINAL COLUMN, AND THE DEFORMITIES RESULTING THEREFROM.

By CLARENCE L. STARR, M.D., Toronto, Canada.

Nomenclature.—In the English language tuberculous disease of the spine is variously known as Pott's disease, caries of the spine, kyphosis, antero-posterior curvature, and angular curvature.

In the French it is called *mal de Pott, mal vertébral, gibbosité,* or *kyphose.*

In the German it is designated *Spitzbuckel, anguläre Rückgratsverkrümmung,* or *Knickung der Wirbelsäule.*

Historical Sketch.—Antero-posterior curvature is known to have existed on this continent in prehistoric times, as is shown by a specimen of Indian remains in the Peabody Museum, Cambridge, Mass. That it was known to the ancients is undoubted, and Hippocrates described the condition and recognized that a relation existed between this and various lung affections. In the commencement of the eleventh century Avicenna mentions the condition, and in 1585 it is more freely described by Ambroise Paré.

It was not, however, until 1779 that the knowledge of this disease was materially advanced. Percival Pott, of St. Bartholomew's Hospital, London, after a careful study of the disease, gave an accurate description of the pathological condition which existed, and described it as a caries of the spine.

No further advance was made until Delpech and Nélaton in 1836 recognized the disease as a tuberculous condition and identical with that existing in the lungs. There was apparently a difficulty in defining clearly what tubercle really was, but a satisfactory conclusion was arrived at by Cohnheim, who described as tuberculous only those conditions which when inoculated into properly constituted animals produced tuberculosis. This view was accepted by Virchow, Rokitansky, and others.

Koester in 1869 made another step in advance when he described the histological structure of a tubercle as made up of a giant cell, with nuclei at one end, this being surrounded by lymphoid cells.

It was not, however, until 1882, when Koch gave his discovery to the world, that the tubercle bacillus was known to be the specific cause of the tubercle, and then the last link was added to the chain.

Anatomical Considerations.—The vertebral column is a flexible column forming the central axis of the body and is situated in the median line of the trunk at its posterior aspect. At its upper end it supports the head, in the middle portion it has attached the ribs, through which it carries the weight of the upper extremities, and at the lower end, through the sacrum, it transmits the weight of the trunk to the lower extremities. Thus it is seen that if trauma may have a part in the causation of tuberculous diseases of bones and joints, the disease of the spine should increase in frequency from above downward, as the weight trauma on the spine is obviously increased from above downward.

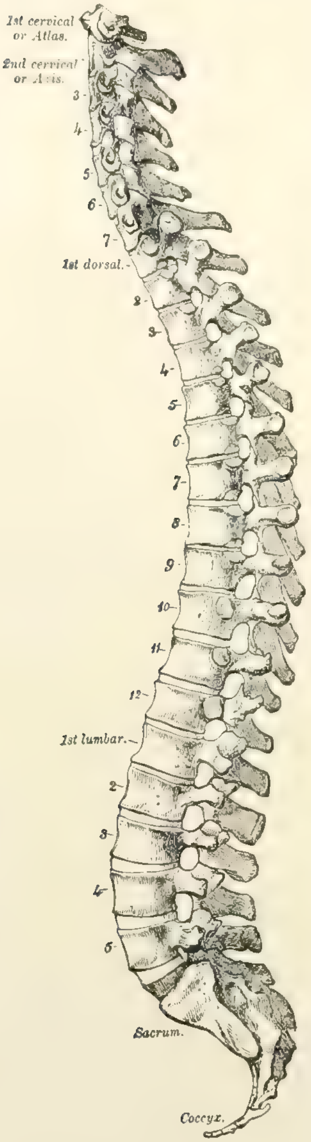


Fig. 683.—Normal Spine. Showing physiological curves. (Morris.)

The spine is not a straight rod, but is made up, as when seen in profile, of a series of curves. (Fig. 683.) This naturally adds to its elasticity, but increases the difficulty of weight-bearing. The two primary or intra-uterine curves are the dorsal, and the pelvic or sacral curves, corresponding to the two cavities of the body, the thorax and the pelvis. These backward curvatures go to the making up of an increased capacity in these two cavities.

The secondary curves with the convexity forward are the cervical and the lumbar ones. These are undoubtedly compensatory in character and go to establish the equilibrium or proper poise of the body. They appear during the first year of life, the lumbar a permanent curve, the cervical a curvature which is obliterated by the dropping of the chin on the chest. These curvatures are made up not so much by a wedge shape of the bodies of the individual vertebræ (Fig. 684) as by variation in thickness of the intervertebral discs (Fig. 685). This allows the weight to be transmitted evenly from body to body through the entire column.

The study of these curves is of importance in determining what happens during recumbency. In a normal individual, if supine on a flat, unyielding surface, the backward curvature of the dorsal spine should prevent any pressure on the bodies of the vertebræ, and if the spine be hyperextended there should be produced a decided tendency to separation of the individual bodies. This shows the method of safeguarding the bodies of the spine which are carious and on the verge of collapsing from pressure.

The bodies of the individual vertebræ are largely made up of cancellous tissue with a very thin layer of compact tissue all around it. The cancellous tissue is arranged with striæ, in a systematic fashion, the striations running, as can be seen on vertical section (Fig. 686), from above downward in a more or less curved manner, with the concavity toward the centre. The fibres running horizontally are also evenly arranged, the striations being slightly curved, with the convexity toward the centre. (Fig. 687.) This cancellous structure, together with the greater blood supply, determines the commencement of tuberculous disease in the bodies rather than in the arches of the vertebræ; these latter being made up almost entirely of compact tissue and with a relatively smaller blood suplpy.

Pathology.—Gross Appearance.—The entrance of the tubercle bacillus into the body of the vertebra is the commencement of a rarefying or degenerative osteitis which is exactly similar to that in the epiphyseal ends of long bones. The disease is almost wholly confined to the bodies or cancellous tissue, partly owing to the greater blood supply to this part, and partly to the lessened resisting power. This disease appears much more frequently in children than in adults, and is undoubtedly due to the same cause, viz., the greater blood supply to the growing bone and the lessened resisting power as compared with the bone of the adult. The laminæ, and the articular, transverse, or spinous processes, are rarely affected either primarily or secondarily.

The commencing osteitis appears to the naked eye as a hyperæmic spot in the spongy bone, usually near its anterior surface. This reddened spot gradually increases in size, and, as in the ordinary process of inflammation, the blood supply to its centre is cut off by the leucocytes blocking the arterioles, resulting in a necrosis of the central area. The central necrotic spot appears opaque and gradually disintegrates, forming the caseous focus so characteristic of tuberculous osteitis.

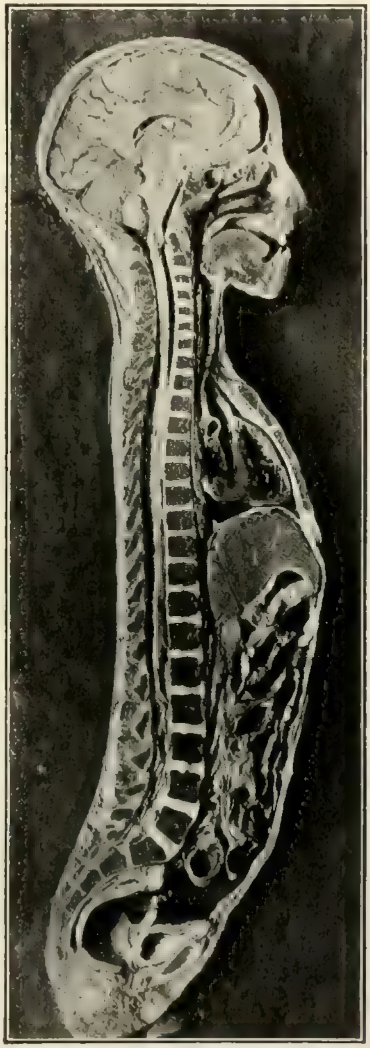


Fig. 684.—Frozen Section. Showing varying thickness of intervertebral discs. (Starr.)

With the caseation and breaking down of the central area the whole picture of a tuberculous focus is complete: The central caseous cavity contains some liquid, the result of chemical changes produced by the toxins; then the caseous bony detritus, mixed with dead leucocytes, makes up the contents of a bone abscess (Fig. 688); this abscess cavity is lined with a layer of granulation tissue which is a protection layer to a greater or less extent; and finally there is a zone of simple inflammatory products—thus making up the complete pathological condition. The tuberculous material may be absorbed or encapsulated at this stage and the disease become quiescent or cured, but, as much more frequently happens, it increases in extent until the whole body of the bone is involved and collapses under the superincumbent weight above the diseased point. (Fig. 689.)

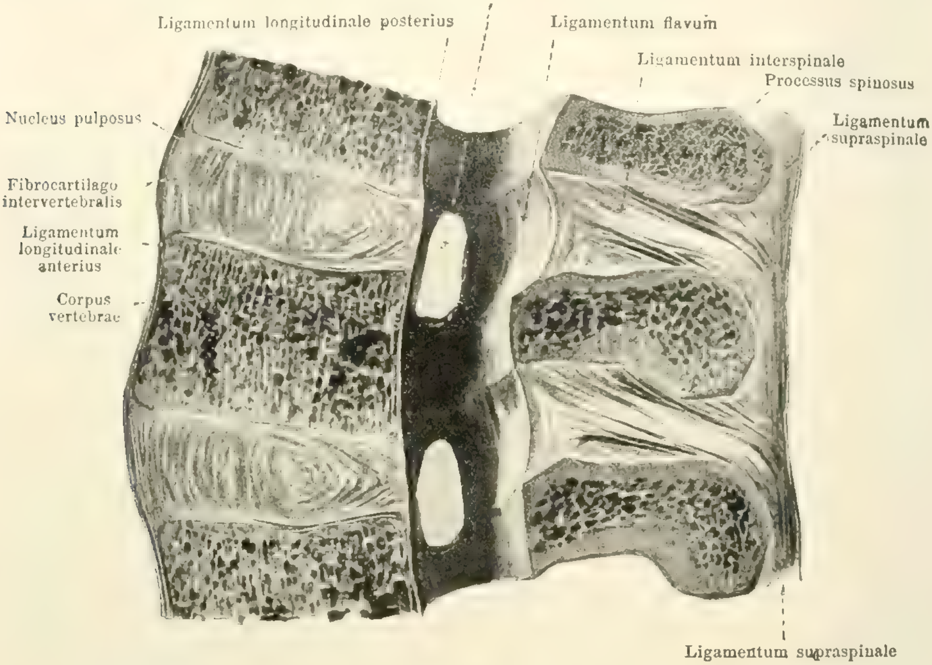


Fig. 685.—Section of Normal Spine. Showing wedge shape of discs. (Spalteholz.)

This crushing in of the vertebral body tips the trunk forward, and at the same time crowds the spinous process backward, producing the sharp angular projection seen in the early stages. The intervertebral discs act as a check to the disease to a certain extent, but they soon give way to the activity of the process and become fibrillated, disintegrate, and disappear. The two bodies next in contact are invaded, caseate, and give way, and the angular projection is increased to three spines instead of one. Thus the disease may extend through a series of vertebræ, sometimes as many as twelve being diseased, with enormous deformity of the spine and thorax resulting.

If the disease, instead of commencing as a focus in the anterior portion of the body, commences in the lateral portion of that body, it is obvious that the body will crush in at the side, and a scoliosis or lateral deviation may result, with little or no backward displacement at the start. This is to be borne in mind in making a diagnosis, as it would be a calamity to treat such a case as one of ordinary scoliosis.

The caseation of the bodies results usually in an abscess which soon escapes by crowding forward the prevertebral ligaments, and forms a pouch beyond the confines of the bony structure. The ultimate condition, in cases which are arrested or cured, is one of fusion of the bodies which have been crushed together, resulting in ankylosis, partially fibrous and partially bony. That a complete, bony ankylosis does occur is shown in some museum specimens. (Fig. 690.)

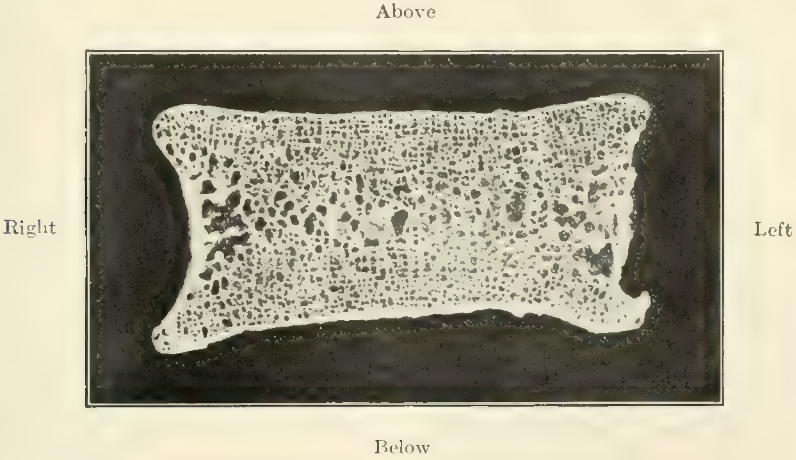


Fig. 686.—Vertical Section of Body of Vertebra. (Spalteholz.)

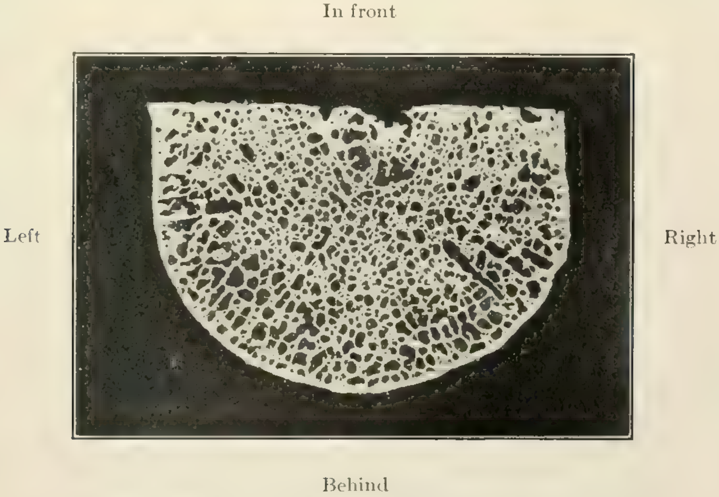


Fig. 687.—Horizontal Section of Vertebral Body. (Spalteholz.)

Histological Structure.—The tubercle bacillus causes certain definite histological changes to take place in the tissues, resulting in the formation of a "tubercle." In the centre of this tubercle is situated a giant cell with its multiple nuclei. These nuclei are usually arranged in a crescentic manner about one end of the cell, although they may occasionally be distributed more or less irregularly through its substance.

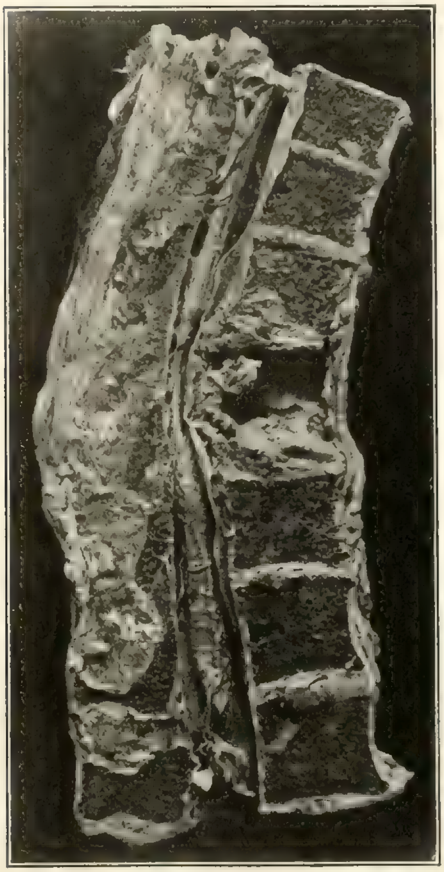


Fig. 688.—Caseation of Body of Vertebra with Bone Abscess. (Joachimsthal.)

Surrounding the giant cell is a layer of "epithelioid" cells, so called from their form. These are larger than the leucocytes and make up the bulk of the tubercle.

Again, on the outside of this layer is a simple inflammatory zone of small round cells. These are the leucocytes. The epithelioid and small round cells are arranged in a reticulum which is made up, according to some observers, of a previously existing connective tissue, into which the cells have simply infiltrated themselves. Others are inclined to think of the reticulum as made up of processes of the epithelioid cells. The reticulum often becomes quite dense at the periphery of the tubercle, forming a sort of membrane around it. A few tubercle bacilli are found in the giant cells and in the epithelioid cells, but none in the inflammatory or leucocyte zone. The paucity of bacilli demonstrable in these tubercles is sometimes thought to be due to a peculiarity of the bacillus in bony tissue, and to a difference in the way it takes the stain. The vascular supply is very poor, if indeed there can be said to be any at all. As a consequence there is a constant tendency to fatty degeneration and caseation in the tubercle. This is, of course, very much more marked when a coalescence of a number of tubercles has taken place. The blood supply to the central ones will obviously be cut off, and the caseation or necrosis already spoken of will more readily take place. In some instances lime salts are deposited freely in the degenerating tubercles, and a cure by calcification takes place.

Compensatory Lordosis.—With the giving way of the body of the vertebra, the portion of the trunk above the diseased part will bend forward, and a stooped attitude will result. In order to regain the equilibrium and to place the head over the centre of gravity a backward bending of the upper trunk must take place. This is assisted by the contraction of the long muscles of the spine which, acting over the kyphus as a fulcrum, tend to bow backward the upper and lower segments. The lordosis takes place at the expense of the compression and expansion of the intervertebral discs and stretching of the prevertebral ligaments.

Changes in the Thorax.—If the disease be in the dorsal region, there are marked changes in the thorax varying with the location of the disease. With upper dorsal disease, the ribs are inclined downward very sharply, and approximated to the spine, the antero-posterior diameter of the thorax being diminished. (Fig. 691.) With a kyphosis in the lower dorsal region, and a consequent compensatory lordosis of the upper dorsal region, the reverse picture will be presented. (Fig. 692.) The ribs are lifted up and become more nearly horizontal. The antero-posterior diameter of the thorax is exaggerated, the sternum is prominent, and the chest is constantly in the position of forced inspiration; so much so, that the chest movements of respiration are to a greater or less extent abolished, and the respiratory movements are largely carried on by the diaphragm.

Pelvic Changes.—In lower lumbar disease or disease of the lumbosacral junction, the angle of the pelvis is altered so that the symphysis is brought nearer the ensiform cartilage; the abdomen is shortened, and the abdominal parietes bulge forward to accommodate the contents. The pelvis assumes the kyphotic shape, the antero-posterior diameter being usually lengthened and the transverse di-

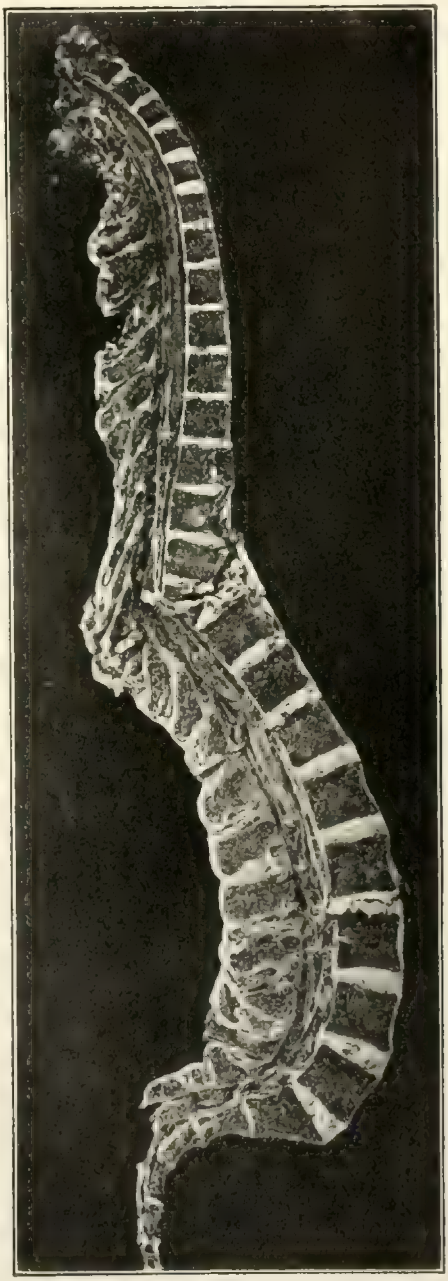


Fig. 689.—Collapse of Vertebral Body Producing Knuckle of Deformity. (Joachimsthal.)

ameter shortened. This makes accouchement very difficult in the kyphotic individual.

Visceral Changes.—The deformity of the spinal column produces some secondary changes in the internal organs. The lungs and heart are seldom affected, except as to position, even in severe deformities. The aorta, being attached closely to the spine, suffers most, and in some instances the kinking of this vessel is so great as to interfere with the perfect blood supply to the lower extremities. (Fig. 693.) Owing to the fact that the vena cava is less intimately attached to the spine, while it is frequently altered in its course, stenosis, or even partial obstruction of the vessel, rarely occurs. The œsophagus is sometimes pouched by reason of the deformity, and occasionally all of these structures are pushed forward by an abscess. Any interference with the abdominal organs is uncommon, although rupture of an abscess into any of the hollow viscera may occur, as instanced by the case of a child in the Hospital for Sick Children, Toronto, in which a psoas abscess ruptured into the cæcum, with only imperfect drainage, and a subsequent operation established a fæcal fistula.

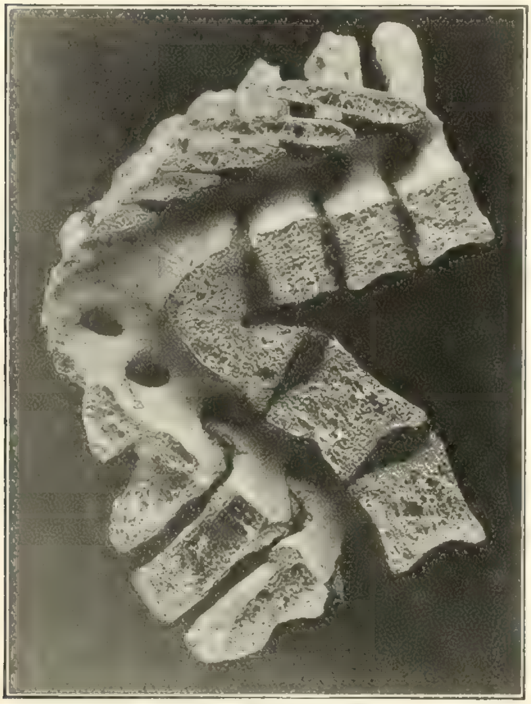


Fig. 690.—Severe Deformity with Fusion of Several Vertebræ. (Joachimsthal.)

Spinal-Cord Changes.—The tuberculous process in the vertebra may extend backward, through the posterior ligament, into the neural canal, and, by invasion of the cord membranes and pressure on the cord, a paraplegia may result. Dollinger in seven hundred cases of spinal caries found forty-one cases of paraplegia, or a little over five per cent. In the Hospital for Sick Children, Toronto, in ninety cases there were seven cases of paraplegia. Taylor and Myers, in some two thousand cases in the New York Orthopedic Hospital, found paraplegia in about thirteen per cent. This is undoubtedly high, and about five per cent would represent the average occurrence.

The paraplegia is due in nearly all cases to pressure from thickening of the membranes and rarely to direct bony pressure, for even in cases of great deformity there is no marked lessening in the size of the neural canal. Occasionally an abscess may form from the posterior surface of the body of the vertebra, or a nodule of bone or sequestrum may be extruded into the canal (Fig. 694), and by direct pressure cause paresis. The common cause, however, is a slow process of extension of the disease into the membranes, producing a pachymeningitis, and this increased granulation tissue makes direct pressure on the cord. The pachymeningitis may produce an interference with the blood and lymph channels and a consequent œdema which may increase the pressure on the cord structure.

The dura mater is very resistant to the attack of tubercle bacilli, and this, no doubt accounts for the fact that the spinal cord is rarely, if ever, the seat of tuberculous disease.

The constant pressure may cause an atrophy of the cord substance and an increase of the interstitial stroma, leading to an ascending or descending degeneration, with ultimately more or less permanent sclerosis. The recuperative power of the cord, however, is very great, and restoration may take place, even after some years.

Abscess.—In possibly fifteen per cent of all cases of tuberculous disease of the spine, an abscess results which can be demonstrated clinically; while post-mortem examinations show a very much larger percentage.

The abscess of tuberculous disease is in reality a cyst, starting primarily in the bone and formed by the coalescence of a number of tubercles which caseate and break down, as previously described. This constitutes the so-called "bone abscess." The abscess, however, rarely limits itself to the bone; the anterior ligaments of the spine become infected, and, in breaking down, they allow the escape of the abscess contents into the soft structures; then, following the line of least resistance, the abscess enlarges, involving more and more of the soft structures in the infection as it proceeds. That the abscess of tuberculous disease is a sterile one, at its commencement and for a great while afterward, is amply proven by bacteriological examination. For example, it has been our custom in the orthopedic service of the Hospital for Sick Children, Toronto, to make an examination, by smear and culture, of the contents of every abscess opened, and it has never been found yet that unopened abscesses, unless the skin is invaded, contain any other organism than the tubercle bacillus. This is of the greatest importance in considering the treatment of the condition.

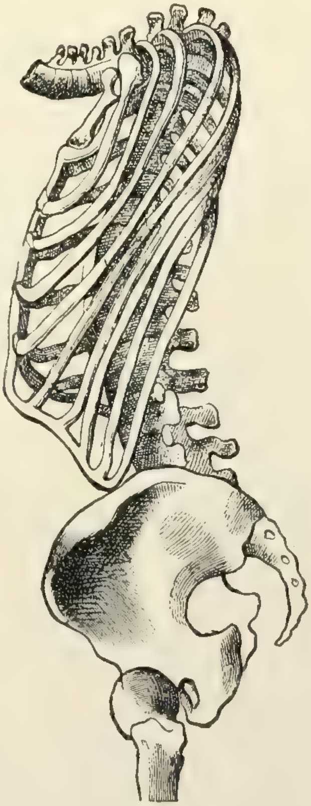


Fig. 691.—Flattening of Thorax in High Dorsal Disease. (Von Bergmann.)

The abscess content is made up, in addition, of a liquefied portion, due apparently to the chemical action of the toxins of the tubercle bacilli on the tissues; floating in this, is a mass of caseous material made up of necrotic bone or soft tissue, the appearance of which is characteristic. Around this, again, is a zone of granulation tissue, which contains the active tubercles. It is in this zone that the disease advances to other structures; and the constant invasion and breaking down of new structures result in new débris being added to the abscess.

The outer zone of the abscess is a simple inflammatory layer and is made up of leucocytes and epithelioid cells. This is to a certain extent a protective layer, antagonizing the advance of the tuberculous process. The abscess at times remains quiescent, or is partially absorbed, and thus tends to spontaneous cure; on the other hand, it much more frequently tends to advance toward the skin surface and open spontaneously. This soon results in a mixed infection, and such infection is the commencement of a chain of symptoms, septic in character, which are much more serious than the original condition.

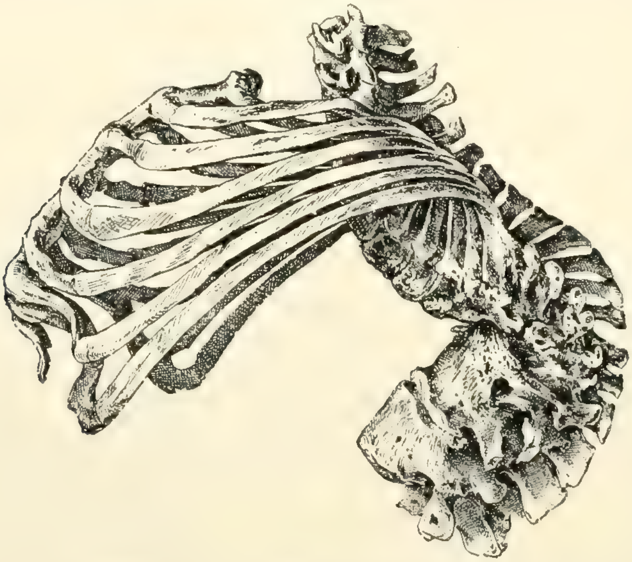


Fig. 692.—Showing Elevation of Ribs in Disease of the Lower Dorsal or Lumbar Vertebræ. (Von Bergmann.)

Etiology.—The essential cause of tuberculous spondylitis is, of course, the tubercle bacilius, as pointed out by Koch. It finds its way to the body of the vertebra through the blood stream. Its entrance into the blood stream is nearly always through some primary focus, most frequently located in the cervical, mediastinal, bronchial, retroperitoneal, or mesenteric lymph nodes. This is so largely the case that one may almost make the dogmatic statement that tuberculous disease of bone is always secondary to some focus elsewhere in the body.

The autopsy findings of some of the German surgical clinics have shown that a large proportion of patients dying of various diseases give evidences of some focus of tuberculosis. This has given rise to the German axiom, "Jederman hat ein bischen Tuberculose." As pointed out by Still, however, the bacillus may find direct entrance to the blood stream through the intestinal villi, or possibly more frequently through the crypts of the tonsils. Occasionally direct infection may take place through an open wound. The statistics of Wullstein, of Halle, as to the relative proportion of cases of tuberculous spondylitis to general surgical diseases are interesting in this connection.

He finds in 100,000 surgical cases in the surgical clinic at Halle 365 cases, or 0.36 per cent, of tuberculous disease of the spine, and, collecting the statistics of other surgical clinics, he finds that the result then stands as follows:

Author.	Surgical Diseases.	Tuberculosis of Spine.	Percentage.
Beuthner	78,297	280	0.36
Billroth	4,100	61	1.5
Hoffa	67,919	142	0.21
Lorenz	32,424	251	0.75
Mohr	4,520	76	1.68
Wullstein	100,000	365	0.365
Total	287,260	1175	0.40

Thus, in a general surgical clinic we find the proportion of cases of spinal tuberculosis relatively large, and in a children's surgical clinic, such as is found in the Hospital for Sick Children, Toronto, the percentage is much larger, as the great majority of these spinal lesions occur during the earlier years of life.

AGE.—Pott's disease may occur at any period from infancy to old age. Several children under two years, at present in the Toronto hospital, show well-marked tuberculous disease; and Thorndike collected 115 cases under two years of age from the records of the Boston Children's Hospital. The great bulk of cases occur during the first decade, and the following table of Wullstein. shows that only 14.7 per cent occur after the twentieth year:

AUTHORS.	No. of cases.	YEARS.									
		1-5	**6-10**	**1-10**	**11-15**	**16-20**	**11-20**	**1-20**	**20-30**	**30-50**	Over **50**
Drachmann	161	66=41%	58=36%	124=77%	22=13%	8= 5%	30=18.7	154=95.7	7=4.3%	......	......
Mohr	73	21=29%	16=22%	37=51%	16=22%	12=16.7%	28=38.7	65=89.7	5=7%	2=2.8%	1=1.4%
Vulpius	96	44=46%	25=26%	69=72%	8= 8%	4= 4%	12=12%	81=84%	7=7%	6=6%	2=2.2%
Wullstein	365	144=39.5	83=22%	227=62%	39=10%	27= 7.4	66=18%	293=80.3	35=9.6	24=6.6%	13=3.6%
Total	695	275=39.6	182=26.2	457=65.8	85=12.2	51= 7.3	136=19.5	593=85.3	54=7.8	32=4.6	16=2.3

SEX.—There seems to be little difference in the liability of the two sexes to the disease. The greater possibility of trauma in the male is offset by the generally weaker resisting force in the female. In a collection of 6,951 cases by Wullstein he finds 3,704, or 53.29 per cent, males, and 3,247, or 46.71 per cent, females.

Heredity.—The part played by heredity is variously estimated by different authors. For instance, Waterman and Jaeger found a hereditary history in about 10 per cent of 1,000 cases. On the other hand, Gibney, in 185 cases, found a previous history of tuberculosis in 76 per cent. In a series of 315 cases of general bone tuberculosis in the Hospital for Sick Children, Toronto, there were 131, or 41 per cent, who gave a distinct history of tuberculosis somewhere in the near relatives, while 73, or 23 per cent, had tuberculous parents.

From these various statistics one may infer that a large percentage of children are directly infected with tuberculous disease from parents. Some have handed down to them a *predisposition* to tuberculous disease, or a lessened resistance to the invasion of the tubercle bacillus.

Trauma.—Krause has demonstrated experimentally that by wrenching or bruising the joint of an animal previously inoculated with the tubercle bacillus, the tuberculous disease will usually appear at the injured point. In a large number of cases of disease of the spine a distinct history of injury is to be obtained, so one concludes that the localizing cause of the disease is a jar or twist, together with the superincumbent weight. The immediate cause is the lowered resistance of the individual who is thus unable to withstand the invasion of the disease.

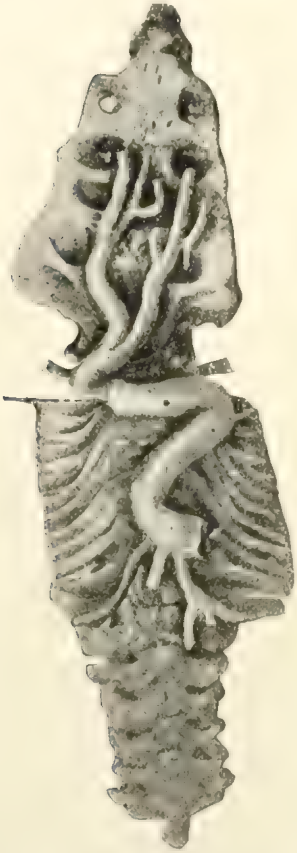


Fig. 693.—Distortion of the Aorta from Crushing Down of Vertebræ. (Bradford and Lovett.)

Localization of Disease.—Any of the vertebral bodies are subject to attack, but the lower dorsal region is the most frequently, and the cervical the least frequently attacked.

Thus in the series collected by Wullstein there were 3,481 cases: of these 468, or 13.4 per cent, were in the cervical; 1,932, or 55.5 per cent, were in the dorsal; and 1,081, or 31.1 per cent, were in the lumbar region.

In a series of 1,271 cases from the Hospital for Ruptured and Crippled, New York, the location was as follows: Cervical 100, dorsal 854, lumbar 317. The fact that there are more vertebræ in the dorsal than in either the cervical or lumbar region, would naturally account for a greater number of cases in this region. The greater amount of cancellous tissue in the lower than in the upper spine would lead one to expect more cases in the lower region. The greatest factor, however, is the possible traumatism, as one finds the greatest number of cases at the hinge regions, the region from the tenth dorsal to the first lumbar being much more frequently attacked than any other.

Symptoms.—In tuberculous disease of joints, irrespective of location, muscular spasm, producing limitation of motion, is the characteristic and earliest symptom. Pott's disease is no exception to this rule. The deformity is the most prominent or most noticeable symptom, but this, being due to destruction of the vertebræ, must be a process of weeks or months, and must be preceded by symptoms of weakness or disability. For a long time the deformity was looked on as the important and diagnostic feature of Pott's disease, and even at the present time the diagnosis is not frequently made before the deformity appears. It should be generally understood that, while many difficulties may present themselves, the diagnosis of Pott's disease before deformity appears is both possible and easy. It is of the utmost importance that an early diagnosis should be made, for once the deformity appears we can scarcely hope for its recession, and it is only by the greatest care that we can prevent it from becoming greater. Gibney has truly said that an early diagnosis is the best treatment.

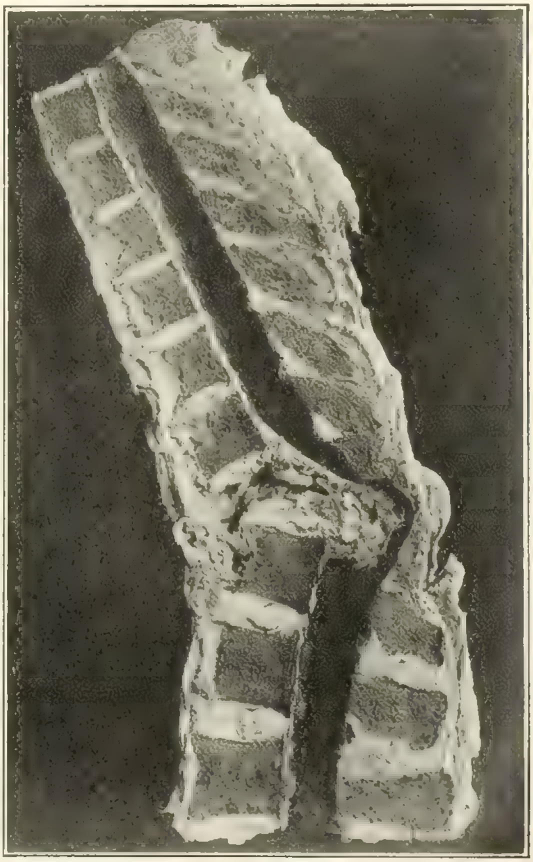


FIG. 694.—Breaking Down of Vertebral Body, with Pressure of Abscess upon the Cord. (Joachimsthal.)

The spinal column has a double function, that of weight-bearing and to serve as a hollow channel for the transmission of the spinal cord. It necessarily follows that any severe destructive process of this column must interfere with the first function, and will produce pain, weakness, and an alteration in the attitude or gait, and may produce changes in the nervous system by pressure or extension of the disease into the neural canal.

Muscular Rigidity.—With the commencement of the disease there come the reflex muscular spasm, and the fixation, or limitation of motion, over a small area at the diseased point, the short muscles of the back alone taking part in the process. This limitation of motion may be noticed only as a slight break in the normal contour of the spine in bending; *i.e.*, the child may still stoop in a natural way, but instead of the normal, evenly rounded curve of the back from the sacrum to the occiput, there is a point at which the curvature has flattened out to a slight extent. Eventually, as the disease progresses, the fixation becomes more extensive, until the whole musculature of the spine is acting to prevent any movement. The extent and intensity of the muscular fixation furnish an indication of the acuteness of the disease.

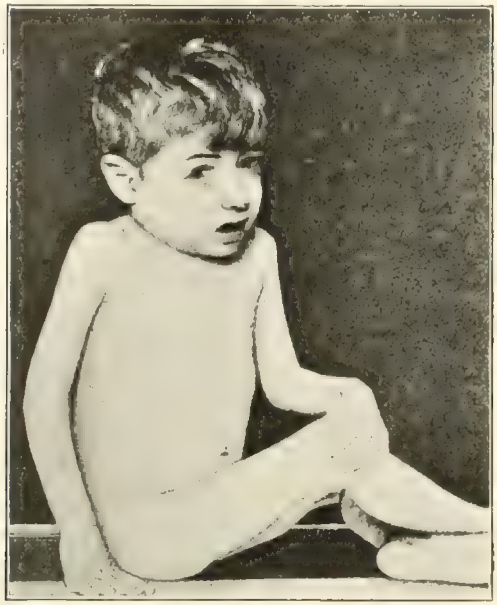


Fig. 695.—Attitude in Cervical Disease. (Whitman.)

The muscular rigidity is noticeable variously in different portions of the spine. In the cervical region the head is fixed so that little or no motion takes place in any direction. (Fig. 695.) The child turns the whole body in attempting to look at any object at the side.

In the dorsal region the act of stooping is interfered with; and instead of bending over to pick up an object, the child squats down, bending knees and hips, but keeping the spine rigid. (Figs. 696 and 697.) This peculiar method of stooping to pick up an object is very characteristic of the acute stage of Pott's disease. The rigidity is demonstrable also by placing the child face downward on a flat surface and lifting the feet. In the normal spine an even curve from heels to occiput is seen (Fig. 698); in the diseased spine a flatness of the back occurs (Fig. 699).

The rigidity of the lumbar spine shows itself in a manner similar to that observed in the dorsal; but there is frequently also a marked hollowness of the spine at this point.

Attitude and Gait.—The characteristic attitude of a child suffering with Pott's disease, both in standing and in walking, is due in part to the muscular fixation, and in part to the effort of nature to protect a sensitive spine from jar.

The gait is one of carefulness, and unnaturalness or awkwardness, instead of the free and easy gait of a healthy child. The walk is on the toes to a large extent, with heels touching the floor very gently, to avoid the concussion incident to a "heel" walk.

If the disease is in the high cervical region, the head is tilted backward,

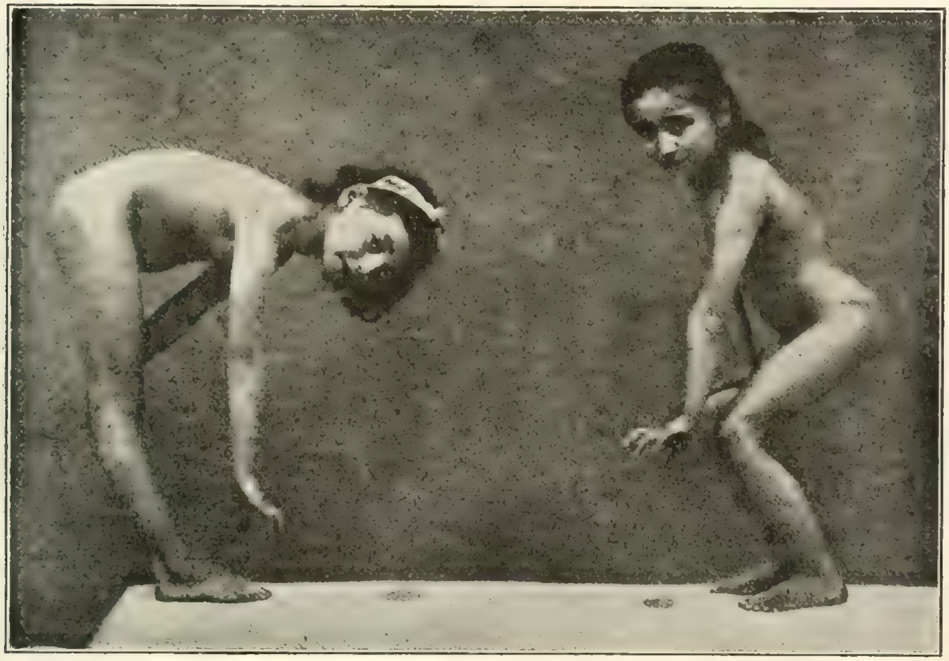


FIG. 696.—Showing Comparison of Normal and Diseased Spine in Attempt to Stoop. (Joachimsthal.)

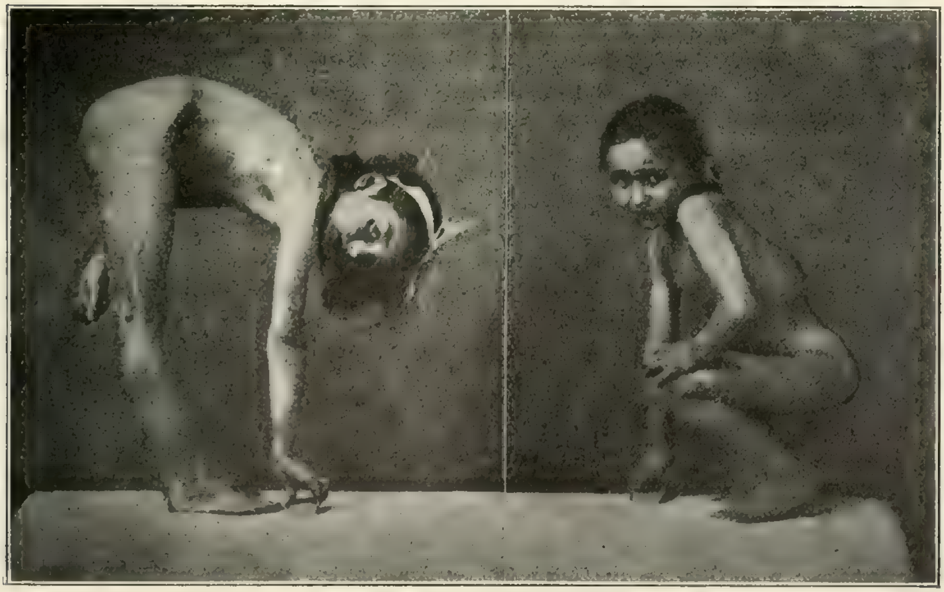


FIG. 697.—Showing Act of Stooping Completed, in Child with Normal and Child with Diseased Spine. (Joachimsthal.)

with the chin elevated (Fig. 700), thus relieving the pressure on the bodies of the vertebræ by carrying the weight back to the articular processes. The head is often supported by the hands (Fig. 701), and the child is frequently found stretched out on the floor to relieve the diseased vertebra of superincumbent weight. Wry-neck may develop from cervical Pott's disease; this is sometimes due to unequal muscular spasm on the two sides, and sometimes undoubtedly due to disintegration of the lateral portions of the bodies of the vertebræ, thus allowing the spine to sink to one side instead of directly backward.

In the dorsal and upper lumbar regions, the attitude is again an unnatural one, that of over-erectness, the so-called military attitude of Pott's disease.

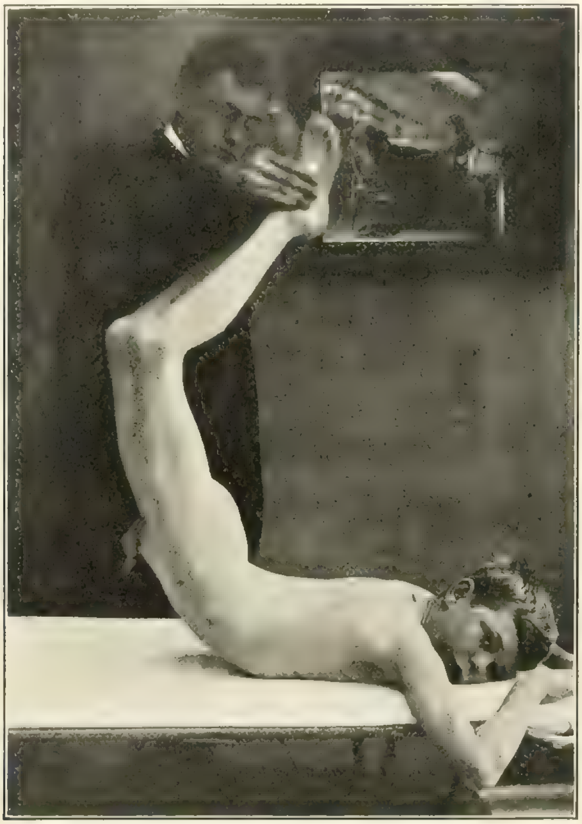


Fig. 698.—Showing Flexibility of the Normal Spine. (Starr.)

The abdomen is protuberant, the shoulders are thrown well back, and all the movements are careful and guarded. The child, instead of playing freely as others do, tires easily, frequently stands with the hands upon the knees, with knees and hips flexed (Fig. 701), thus carrying the weight of head and upper trunk, through the arms, to the lower extremities. A very common position for a child to assume, with disease in this region, is to lie on its stomach across a chair or across the parent's knees. In attempting to rise from a stooping

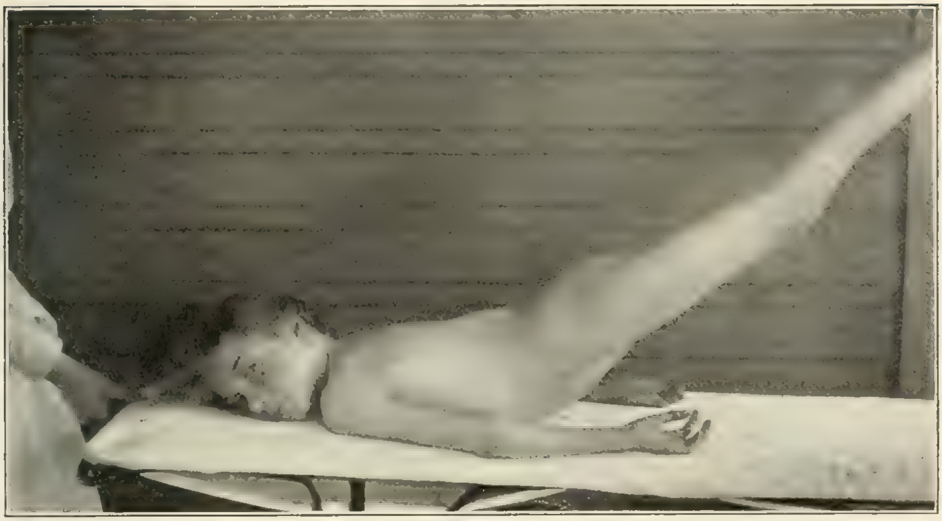


Fig. 699.—Showing Rigidity and Flatness of Diseased Spine. (Starr.)

position the child climbs up himself by placing one hand after the other on knee and thigh. In the sitting posture the hands are placed flat on the floor with the arms straight, to help support the spine (Fig. 703).

In the lumbar region the hollowness of the spine and the protuberance of the abdomen are more marked than in the dorsal region. There is also a peculiar sidling or shuffling gait which is characteristic in disease of this region. In not a few cases a side tilting of the body is present, with flexion of the thigh and leg, the toes only touching the floor. This is due to spasm of the psoas and iliacus muscles and is usually the forerunner of a psoas abscess.

Pain.—Pain in Pott's disease is a very variable symptom. It is usually present, but varies from a sensation of weakness or weariness to a severe type of girdle pain. The pain is due to pressure on the nerve roots as they emerge from the intervertebral foramina. The pressure is very exceptionally caused directly by bone, but in nearly all cases it depends upon the inflammatory thickening of the meninges, with more or less œdema. This irritation of the nerves induces a pain referred to the peripheral endings, and for that reason the pain is misleading, and the disease

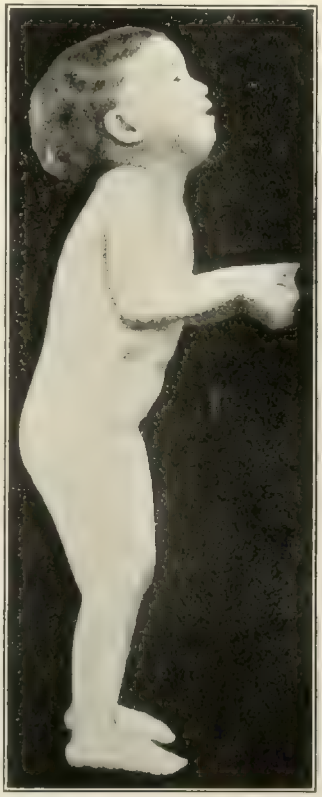


Fig. 700.—Characteristic Attitude in Disease of the Cervical Vertebræ. (Whitman.)

of the spine is consequently apt to be overlooked. Depending on the location of the disease, the pain appears as a neuralgia in the neck or upper extremities, if the location is in the cervical region; as a pain over the sternum and chest, or as a girdle pain in the upper abdomen, if in the dorsal region; and as a sciatic pain in lumbar disease.

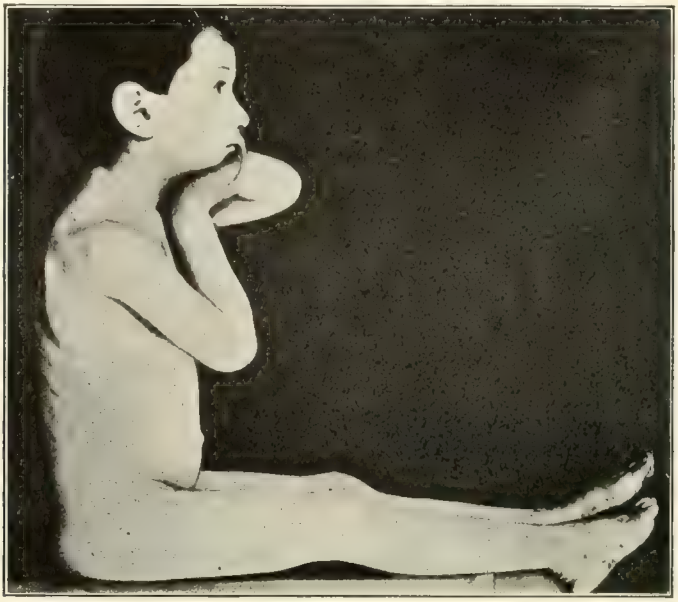


FIG. 701.—Supporting the Head on the Hands in Disease of the Cervical Vertebræ. (Whitman.)

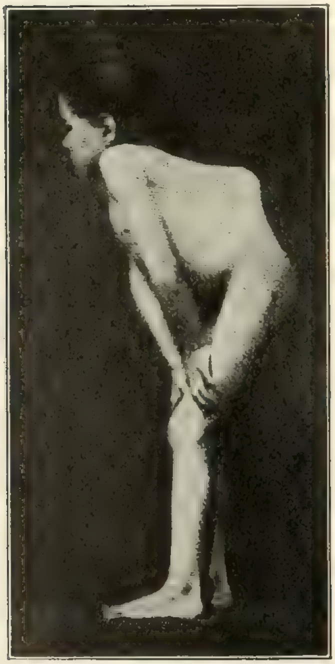


FIG. 702.—Characteristic Attitude in Pott's Disease of Dorsal Spine. (Joachimsthal.)

The referred pain of Pott's disease is as characteristic as the referred knee pain in hip-joint disease, so that a careful examination of the spine should be made in all cases of persistent stomach ache or pain in the chest or extremities. A pain continuing for some time, relieved by position, should, especially in children, at once arouse suspicions of a diseased spine, and should not be considered as colic or "growing pains." There is another type of pain sometimes found, which is of the same character as the "night cry" of hip-joint disease. The muscles of the spine which are in a state of tonic spasm, or as is commonly stated are "on guard," to protect the diseased area, relax during sleep, and then any movement of the patient incites the spasm and the muscles come "on guard" again so abruptly as to jar the diseased portion, and a sharp pain is the result. The pain is often productive of a typical "night cry" or shriek, which may awaken the patient only temporarily. He drops off to sleep again only to repeat the process at frequent intervals during the night. This night pain is readily relieved by fixation of the spine in a plaster jacket or by the position of hyperextension on a frame or cuirass. Pressure over the spines of the diseased vertebræ does not elicit pain, so no information is to be gained that will assist in diagnosis by any percussion of the spines, as is so often practised. The disease being located in the body of the vertebræ, with the spines and laminæ free, one should not expect any pain, and yet the fact that pressure on any vertebral spine does not produce pain is often taken to mean that no disease is present.

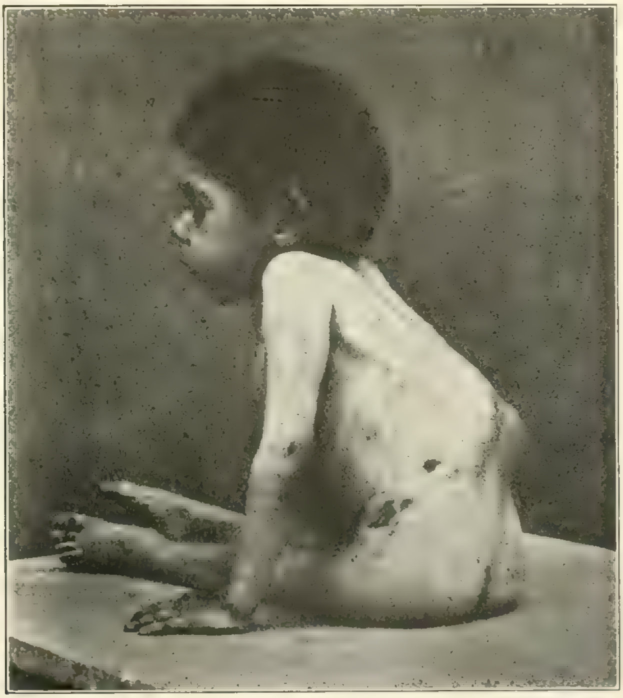


FIG. 703.—Supporting the Spine by the Arms. (Joachimsthal.)

DEFORMITY.—The deformity is the commonest and most characteristic, although, as will be readily understood, not by any means the earliest, symptom of tuberculous spondylitis. In the early stage it is usually sharply angular and projects directly backward as a knuckle, one spinous process extending distinctly beyond the others. As more of the bodies are invaded and become broken down, their spines project backward with the primary knuckle leading. (Fig. 704.) There is some slight compensatory lordosis, above and below, which makes the kyphus still more prominent. In the later stages of the disease, when the tuberculous process is cured or quiescent, the angularity of the kyphus gradually disappears, and a rounded prominence results. (Fig. 705.)

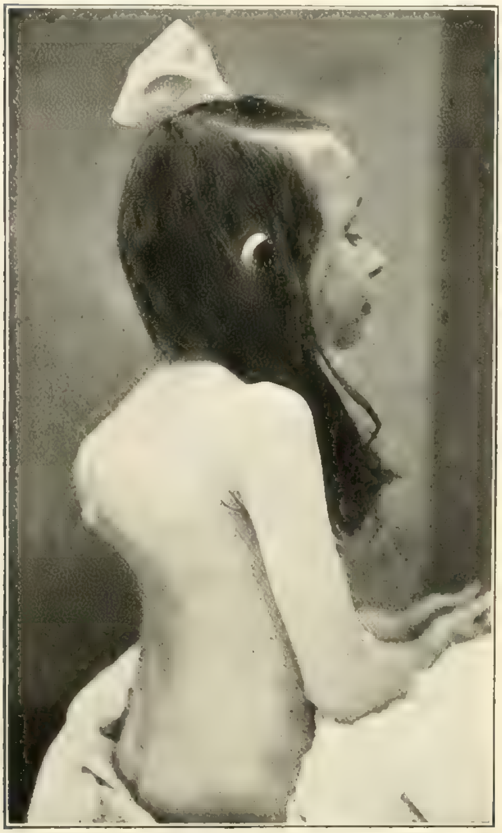


FIG. 704.—Deformity with Extensive Disease Fairly Acute. (Starr.)

In this way it is seen that the appearance of the kyphus, *i.e.*, its sharp or rounded character, is an indication of its acute or quiescent character. This is not absolute; for in some cases, where the focus of disease starts in the epiphyseal edge of the body and invades the intervertebral disc (Fig. 706), the disease may be acute and the resulting deformity appear more rounded than angular. In some cases also of disease in the upper dorsal vertebræ, the kyphus may be quite rounded, resembling very largely in appearance the postural curve of "round shoulders." Sufficient attention has not been drawn to the fact that the deformity of Pott's disease is not always backward. If the focus of disease commence in the lateral portion of the body instead of in the anterior, the knuckling of the vertebræ will be sharply to the side, and a lateral deviation will result. (Fig. 707.) This must be ever kept in mind when examining cases of lateral curvature, as sometimes patients with Pott's disease who presented this lateral deviation have been treated by active gymnastics with most disastrous results. There ought to be no difficulty in differentiating these conditions, for besides the limitation of motion in the spine and the sharpness of the curve to the side, there is, as pointed out by Lovett, no rotation of the spine in Pott's disease, *i.e.*, the lateral curvature is a true lateral deviation.

In the disease of the last lumbar vertebral body, with crushing in of its substance, there may be a forward displacement or sharp lordosis of the spine at this point on account of the fixity of the sacrum, and thus one sees frequently in this condition a sharp recession or hollow point above the prominent first sacral spine.

The deformity may vary from the small knuckle of a single vertebra to the enormous hunchback involving nearly all of the dorsal vertebræ. This huge deformity is fortunately not so common in these recent days as formerly, owing, no doubt, to earlier diagnosis and more efficient treatment.

Complications.—Abscess.—One of the symptoms, which may be looked upon as a complication of Pott's disease, in that it is not always present, and is in a degree preventable, is the abscess.

That it is a dangerous complication is undoubted, for while it is considered by some surgeons as only a symptom of a serious disease and therefore worthy of but a passing notice, yet in the mind of the author it is responsible for the great bulk of the deaths that occur in the course of tuberculous disease of the spine. For this reason a fuller consideration than may seem at first warranted in a necessarily limited article, is given to the causation, course, and treatment of this complication. The formation and contents of a true tuberculous abscess have been considered under the pathological structure (see page 930); hence a brief mention is all that is necessary here of the special symptoms which appear coincidently with the abscess under certain conditions, and the symptoms which follow the abscess in special locations.

An abscess of small dimensions, deeply buried in the tissues, will contain in practically all instances only the tubercle bacillus as a definite organism. The contents of such an abscess are sterile, so far as the presence of any other organism is concerned. This type of abscess is innocuous and, contrary to the usual teaching, the temperature of the patient will not be elevated in the evening beyond the normal range. In the Hospital for Sick Children, Toronto, the author has noted in a series of cases the temperature charts of healthy children, such as those with club-feet and bow-legs; of children with tuberculous disease of bones without abscess apparent, and of children with tuberculous disease complicated with abscess, and they all show a similar temperature chart, with no more variation from the normal in one class than in the other.

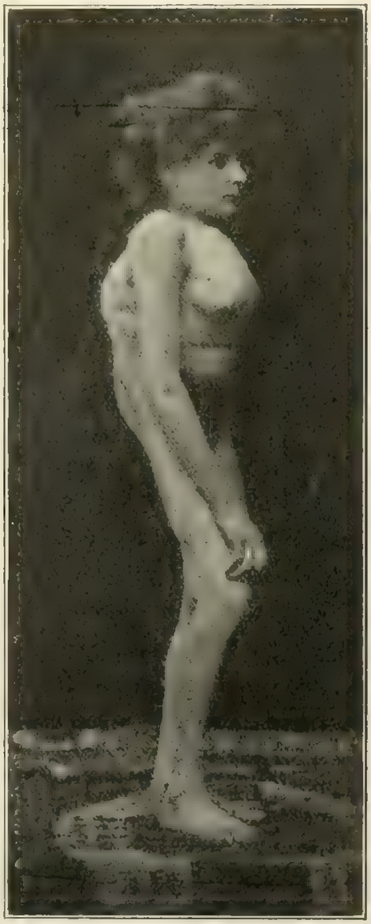


Fig. 705.—Rounded Deformity in Long-standing Pott's Disease, Showing also the Elevation of the Ribs in Lower Dorsal Disease. (Joachimsthal.)

If this abscess remains uninfected and shows no signs of increasing in size, but on the contrary tends to decrease by absorption of its contents, then the disease will run its course as would a case without abscess. If, on the other

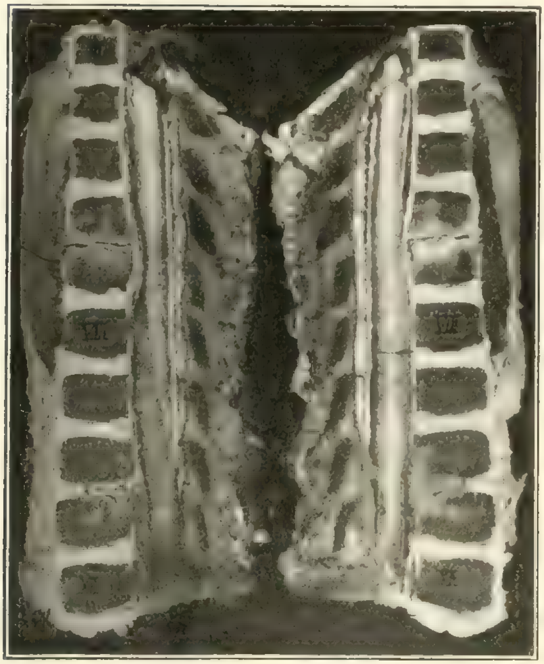


FIG. 706.—Disease Commencing in Epiphyseal Edge of Vertebral Body and Showing little Deformity. (Joachimsthal.)

hand, the abscess enlarges, and, moving along the line of least resistance, approaches the skin surface or opens spontaneously, an infection of the cavity with staphylococci or streptococci will almost certainly take place, and one sees the usual chain of symptoms supervene which always follow a mixed infection, viz., the temperature is elevated several degrees in the evenings, the patient shows a hectic flush in the cheeks and begins to lose appetite and ambition, night sweats appear, in fact all of the symptoms are those of sepsis. If a fistula has been established, the abscess cavity will continue to discharge indefinitely; and amyloid changes in the viscera, particularly in the kidneys and liver, will appear. The author has yet to see a case of amyloid degeneration in tuberculous bone disease in which there has not first been a mixed infection. It is to be noted that while the chief source of this mixed infection is undoubtedly from a spontaneous rupture of the abscess, yet infection may take place through the blood stream while the abscess is yet deeply situated; or, as is more usual, the abscess becomes infected through contact with the crypts of the sebaceous glands as it approaches the skin. In either case the onset of the mixed infection is noted by the change in the temperature chart from the normal range to that of septic character. This shows the imperative need of interference with an abscess exhibiting definite symptoms of enlargement and approach to the surface, in order to keep the cavity sterile.

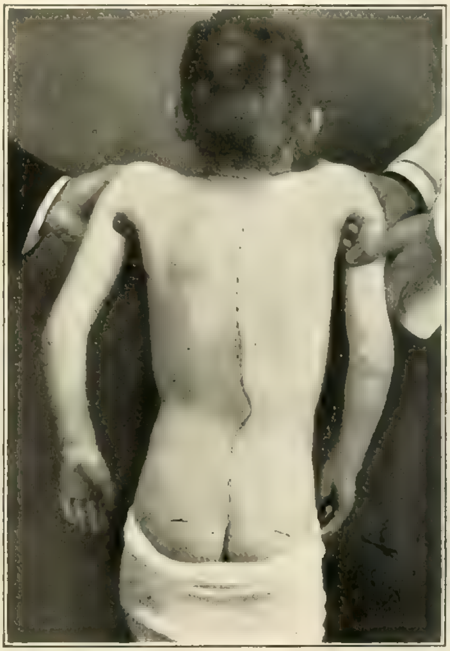


FIG. 707.—Sharp Lateral Deviation Sometimes Found in Pott's Disease. (Starr.)

The abscess shows somewhat varying symptoms and appearance depending upon its location. In disease of the occipito-atlantal joint the abscess has been known to wander up through the foramen lacerum posterius and cause thrombosis of the lateral sinus. (v. Bergmann.) Generally an abscess of either of the first two cervical vertebræ will appear under the mucous membrane of the pharynx as a retropharyngeal abscess (Fig. 708), and symptoms of obstruction to nasal respiration appear. The little patient breathes with the mouth open and talks with a nasal twang.

In the middle of the cervical region, from the third to the fifth vertebra, the abscess may also show as a retropharyngeal or retro-œsophageal abscess; but much the commoner location is to find the abscess perforating the deep fascia and appearing in the neck either just in front of or just behind the sterno-mastoid muscle. The abscess in this region may cause compression of the brachial plexus and consequent pain in the upper extremity.

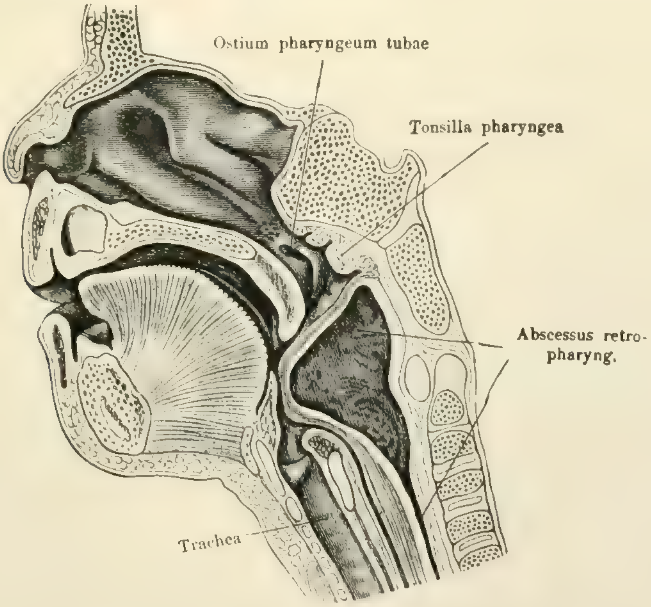


FIG. 708.—Retropharyngeal Abscess. (After Zuckerkandl.)

The vertebral artery has been eroded by an abscess of the cervical vertebræ. In the lower cervical and upper dorsal regions, the abscess follows the anterior ligaments of the spine and develops to a greater or lesser extent in the posterior mediastinum behind the œsophagus and under the arch of the aorta. Abscesses of this region rarely show any symptoms, although they have been described (Joachimsthal) as causing sufficient pressure on the œsophagus and trachea to obstruct breathing and to require a tracheotomy for relief. The wanderings of an abscess in this region may be very extensive. It may follow the aorta downward through the aortic opening in the diaphragm, along the descending aorta, branching with the common and external iliac arteries, and appear under Poupart's ligament. The abscess of the dorsal vertebræ may also follow the course of the intercostal vessels, and appear at any portion of the posterior or lateral chest wall.

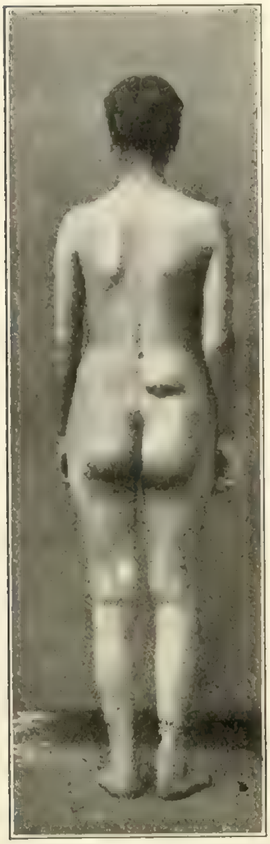


FIG. 709.—Lumbar Abscess. (Joachimsthal.)

In the disease of the last two dorsal and all the lumbar vertebræ the abscess not infrequently points above the crest of the ilium posteriorly, as a lumbar abscess (Fig. 709), but the common type is the psoas abscess. This follows the psoas muscle downward under Poupart's ligament (Fig. 710) to its insertion in the lesser trochanter, and here may burst through the psoas sheath and infiltrate the tissues of the inner side of the thigh (Fig. 711).

The commencement of a psoas abscess causes characteristic symptoms, even before any thickening may be palpated. The thigh is slightly flexed, and rotated inward, and the patient bends to the affected side.

The method of testing for psoas abscess is to place the patient face downward on a hard surface; and, after flexing the leg on the thigh, an attempt is made to hyperextend the thigh. (Fig. 712.) In the normal child the thigh will extend about fifteen degrees, but in psoas contraction no such hyperextension is possible.

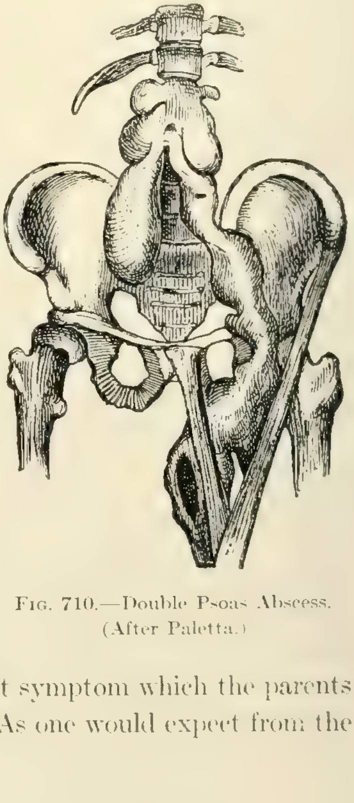


FIG. 710.—Double Psoas Abscess. (After Paletta.)

PARAPLEGIA.—The thickening and œdema of the membranes of the cord, due to secondary extension of the tuberculous process from the bodies of the vertebræ, produce in some cases a compression myelitis and ultimately a sclerosis of the cord, which result in paraplegia. This compression is rarely due to direct bony pressure, and consequently the paraplegia may occur in cases with very slight deformity. In one case admitted into the Hospital for Sick Children, Toronto, the paraplegia was the first symptom which the parents noted, no deformity having yet presented itself. As one would expect from the narrowness of the neural canal in the dorsal region, the large percentage of cases of paraplegia is found in disease of the dorsal vertebræ; next to this they occur in the cervical region, and rarely are any cases found in the lumbar region.

The symptoms accompanying this complication are marked spastic rigidity of the muscles of the lower extremities, exaggeration of skin and patellar reflexes, and ankle clonus. The sensation is usually normal, and the bladder and bowels are rarely affected.

Diagnosis.—An early diagnosis is absolutely essential if a recovery of function in the spine is to be hoped for. This early diagnosis also results in a great saving of time in which recovery may take place; and it may eliminate the suffering and permanent disability which result if a diagnosis is not made until the later severe destructive stages have been reached. The writer is convinced that a large proportion of the cases of Pott's disease which have been overlooked, or wrongly diagnosed as "growing pains," "rheumatism," or "strain," would have been detected or at least suspected, if a careful and systematic examination had been made. Therefore, one would urge that in *all cases* of children presenting themselves with a history of persistent abdominal pain, a peculiarity of attitude or gait, or a complaint of being easily tired, a careful examination of the spine should be made with the child stripped of all clothing.

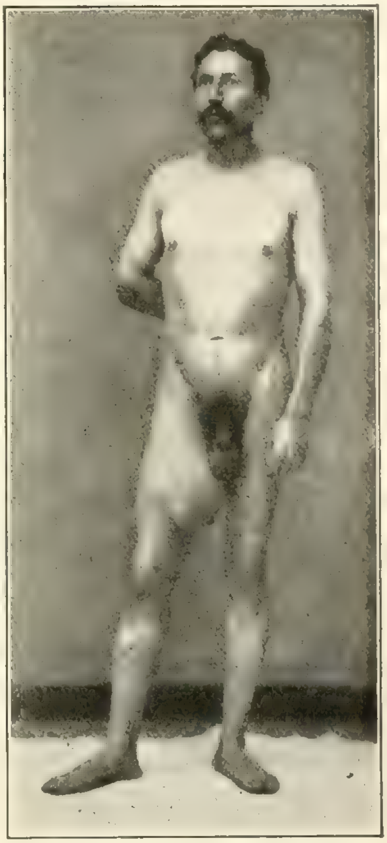


FIG. 711.—Psoas Abscess, after Bursting through Psoas Sheath, Pointing on Inside of Thigh. (Wullstein.)

One other general statement should be borne in mind, that an absence of pain does not necessarily mean an absence of Pott's disease, as the disease may progress for months and give rise to no pain whatever. The symptoms which have been very aptly termed the "trinity of Pott's disease" are the kyphus, the abscess, and the paralysis—the presence of any one of these may be enough to render the diagnosis absolute, but the combination of all of them is proof positive of the existence of the disease. Of course, when any or all of these symptoms are present the disease has progressed to a considerable extent and permanent destruction has taken place, with consequent loss of function. In nearly all cases a diagnosis is not only possible, but simple, before any of these cardinal symptoms which are due to bony destruction have appeared.

The early diagnostic symptoms are those which arise from the muscular rigidity or spasm, and are noted in the peculiarity of gait or attitude and the limitation of movement of the spine. The examination for detection of these symptoms should be made carefully and systematically somewhat as follows: the child, stripped, is required to walk up and down before the examiner. Due regard should be given to the fact that a child of eight or ten years of age may show some hesitation in parading nude before a stranger, but with a little tact and perseverance the child can soon be persuaded to walk unconsciously. The gait will be noted as one of carefulness, and not the free swing of a child with a normal spine. The walk will be with the weight carried forward on the toes, the heels touching lightly, if at all, in order to prevent the jarring of the spine which results from the ordinary heel gait.

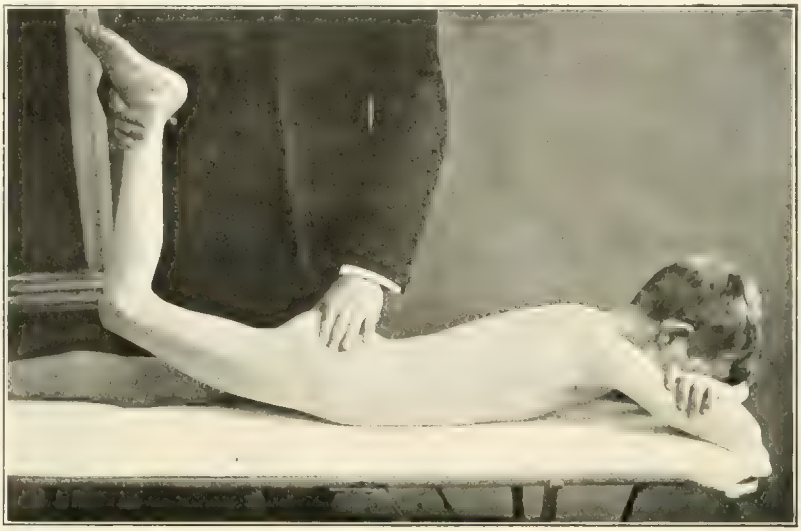


FIG. 712.—Normal Hyperextension of Thigh. (Starr.)

The attitude will vary according to the location of the disease. In the *cervical region* the position of the head is erect, with the chin tilted upward and carried somewhat forward of the normal position. The head is also held with a good deal of rigidity, and in looking upward or downward the eyes are rolled as far as possible, and little movement of the head is made. In a like manner, if the child with cervical Pott's disease wishes to look to the side, the shoulders and trunk accompany the movement of the eyes with little or no rotation of the cervical spine. It should be remembered, also, that in a fairly large number of cases of disease of the cervical spine, the muscular spasm is unequal and torticollis is the result. It is, of course, absolutely necessary that this should not be mistaken for an ordinary case of wry-neck. The attitude of the child when tired, with the chin resting upon the hands, as in Fig. 701, is characteristic.

In the *upper dorsal region* the symptoms will be almost identical with those in the cervical region as described above. In the *mid-dorsal region* there is the same careful gait, the patient walking on the toes, but added to this there is the hyper-erect position or military gait with the shoulders square and thrown backward. The parents will sometimes resent the suggestion that there can be any disease of the spine on account of the erect attitude, which they point out with no little pride. It is, however, in practically all cases an unnatural attitude for a child, and as such should excite suspicion of Pott's disease. In this region, on account of the backward curvature of the spine, very slight destruction in the bodies shows itself as a knuckle protruding backward, and hence the deformity may be almost the earliest symptom.

In the *lower dorsal region* the symptoms are so nearly like those of the lumbar region that they may be described together.

In the *lumbar region*, for an early diagnosis one must depend almost entirely on the symptoms of muscular rigidity and limitation of motion, as the deformity may be very late in showing itself on account of the anterior curvature of the spine in this region. The patient exhibits the same carefulness of gait as when the disease involves other regions of the spine. There is also a protrusion of the abdomen, with some lordosis of the lumbar spine, the child thus unconsciously protecting the diseased bodies of the vertebræ by throwing the weight back upon the articular processes. The motions of the spine are exceedingly limited, rotation is prevented and the child in turning to the side turns the whole trunk. In attempting to pick up an object from the floor, the knees and hips are bent and the patient squats to the floor with the spine held rigid, instead of stooping with the whole spine arched. (Fig. 696.) In the very early stage, while the spine still bows in an attempt to pick up any object, it will be noted that there is a rigidity of a certain portion of the spine; that is, there is a flattening in a section of the spine, and a break is noted when compared with the smooth arch of the normal spine. (Fig. 713.) In recovering the erect position, the hand is usually placed upon the knee and the patient climbs up himself. The position of fatigue is also characteristic. The child with Pott's disease in this region will often stand with the thighs flexed and the hands resting upon the knees. (Fig. 702.) In sitting, the patient will support the weight

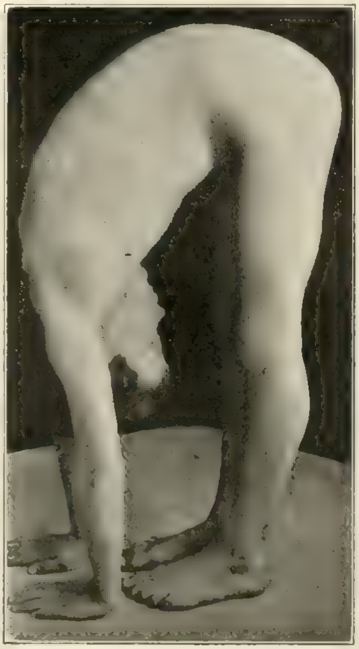


FIG. 713.—Showing Normal Roundness of Spine in Stooping. (Starr.)

of the upper trunk through the arms, resting the hands flat upon the floor. (Fig. 703.)

The thigh of one side is frequently seen in a position of slight flexion (Fig. 714), due to psoas irritability or to a commencing abscess. The psoas spasm may be detected by placing the child face downward on a flat, hard surface and attempting to hyperextend the thighs with one hand placed upon the buttock to hold it down. The normal thigh will hyperextend about fifteen degrees (Fig. 712), but the one with psoas spasm shows no hyperextension. The rigidity of the spine may be excellently shown without danger by placing the patient on a table with the face downward, and lifting the heels. The normal spine is seen to arch evenly from the neck to the sacrum (Fig. 698), while the diseased one will be flattened to a greater or lesser degree, depending upon the extent of the disease (Fig. 699).

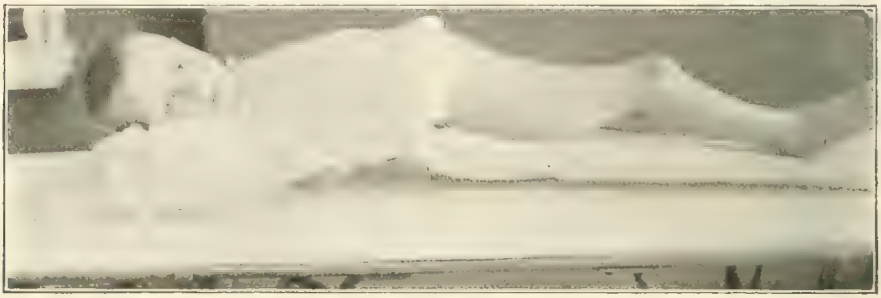


Fig. 714.—Flexion of Thigh from Psoas Contraction in Commencing Psoas Abscess. (Starr.)

When pain is present, it is usually described as radiating, and is referred to the peripheral endings of the nerves. It is usually relieved by recumbency. The referred pain of Pott's disease is as characteristic as the pain in the knee of hip-joint disease. As pointed out in the section on symptomatology (page 945) pressure on the spine does not cause pain. The writer wishes here to protest against the methods advocated in many text-books, of attempting to gain information of diagnostic value by making pressure upon the head of a patient suspected to have tuberculous osteitis, or of bringing the hands down smartly upon the shoulders of the patient, or of asking him to jump from a chair to the floor to see if it causes pain or discomfort. Any information to be gained in this way can be easily obtained by adopting the methods previously recommended, and it will readily appear that if the body of a vertebra is largely diseased, this barbarous method may be the cause of the breaking down of a body which otherwise might have been prevented.

The *diagnosis of abscess* is simple when it becomes large, as by inspection alone it can be readily located. The frequent appearance of a psoas abscess on the inner side of the thigh should be remembered (Fig. 711), as it is often mistaken for an abscess of hip-joint disease. A retropharyngeal abscess may be easily overlooked, but the nasal speech and mouth-breathing associated with the rigidity of the cervical spine should lead to careful examination of the throat, when the bulging of the posterior pharyngeal wall can be both seen and felt.

An abscess of the mediastinum can be diagnosed only by the pressure symptoms which it may produce on the œsophagus or trachea or on the great blood-vessels. An abscess in the psoas sheath can usually be detected by palpation deep in the iliac fossa, where a fulness may be felt. At the same time this is commonly accompanied by psoas contraction, which is detected as described above.

The diagnosis of paralysis, when complete, is made from the fact that it is a paraplegia of spastic type, with exaggerated patellar reflexes and ankle clonus, usually accompanied by a kyphus in some portion of the spine. Before there is complete paraplegia, however, one should suspect the commencement of paralysis from the tendency of the toes to drag and a heaviness of the feet, accompanied even at this early stage by exaggerated patellar reflexes.

DIFFERENTIAL DIAGNOSIS.—*Carcinoma* occurs usually in adults, while tuberculous spondylitis is essentially a disease of childhood. Carcinoma is rarely found as a primary focus in the spine, and by the time the spine is affected the primary focus will be so prominent as to render the diagnosis of malignant disease probable. Where there is any deformity it is generally more rounded than the kyphus of Pott's disease. The pain resulting from carcinoma of the spine is a more prominent symptom, while the stiffness and paralytic symptoms may be similar. If the disease is of long standing the cachectic appearance will aid in the diagnosis.

Sarcoma of the spine is rare in children, and when present it usually appears as one focus of a multiple lesion. In the early stage, if the disease is primary, it may be difficult or impossible to differentiate from Pott's disease, but the rapidity of growth of the sarcoma soon leads to a positive diagnosis.

Aneurism of the aorta may produce an erosion of the spine and cause a deformity which may simulate the kyphus of Pott's disease. The bruit and circulatory changes will clear up the diagnosis.

Syphilis, either in childhood or in adult life, occurs more frequently than is commonly suspected. Some of the cases reported as tuberculous disease of the spine which have made rapid recoveries were undoubtedly of syphilitic origin. In the child, a parental history of syphilis, with enlargement of the postcervical and epitrochlear glands and the notched teeth, should make us suspect syphilis. In the adult, the presence of hard or soft chancres, the saddle nose, and the gummatous periostitis will render the diagnosis of syphilis probable. A course of antisyphilitic treatment will clear up the diagnosis completely.

Typhoid spine rarely causes any deformity; it follows reasonably soon after an attack of typhoid fever, and is more frequently found in adults than in children.

Spondylitis deformans is found in adult life and is generally associated with an arthritis in other joints of the body. There is a general arching of the spinal column with rigidity, but without muscular spasm, the ribs being frequently ankylosed so that no motion of the chest wall is possible.

Osteomyelitis and other acute infections are occasionally found. The acuteness of the symptoms, severe pain, with elevation of the body temperature, serve to differentiate these.

Spondylolisthesis shows itself as a displacement of a vertebra forward on its neighbor. It occurs in the lumbar region, and has not the marked muscular spasm of tuberculous disease.

Scoliosis is marked by rotation of the spine on its long axis, and there is no rigidity or fixation of the spine. The limitation of motion is purely a mechanical one, due to overlapping of the ribs. The lateral curvature in Pott's disease is a pure lateral deviation without rotation of the spine.

Wry-neck of congenital type is diagnosed by the history, together with the fact that the muscular spasm is confined to one muscle or to a group on one side of the neck. In wry-neck due to Pott's disease there is a general muscular spasm. The diagnosis is readily cleared up by placing the patient in a recumbent posture on a Whitman frame with the cervical spine somewhat hyperextended. In Pott's disease the muscular spasm will relax in a few days, and the deformity will disappear.

Sprain is the result of a trauma and appears at once after an injury. A short rest clears up all symptoms.

A neurotic or "railway spine" is often difficult to differentiate accurately, but the predominant symptoms are subjective, the pain is greater, the spines are sensitive to pressure, and all symptoms are exaggerated.

In the *rhachitic spine* the deformity is more rounded than in Pott's disease. The muscular rigidity is very much less marked, the movements are comparatively free, and the other symptoms of rickets are generally present, *i.e.*, beading of the ribs, enlargement of the epiphyses, prominence of the forehead, protrusion of the abdomen, sweating of the head, etc.

Occasionally the psoas spasm of lumbar Pott's disease may be mistaken for *hip-joint disease*, but they can be readily differentiated if it is remembered that there is limitation of extension only in psoas spasm, all the other motions at the hip, *i.e.*, flexion, adduction, and abduction, with rotation, remaining free. With the psoas contraction of lumbar Pott's disease, also, the limb is flexed, adducted, and rotated inward, while the position of the limb in early hip-joint disease is one of flexion, abduction, and outward rotation.

The reaction to tuberculin may assist in confirming the diagnosis of tuberculous spondylitis.

Prognosis.—Tuberculous spondylitis is to be regarded as a very severe affection. In a general way one may say that the disease tends to spontaneous recovery, but with a greater or lesser degree of deformity. In the cervical spine, on account of the small size of the bodies and the relatively less superimposed weight, the deformity may be slight. In the dorsal region, however, the degree of deformity may be enormous, sometimes involving the whole dorsal spine. There is perhaps no other disease in which the results capable of being obtained by proper treatment are more noticeable than in this. If an early diagnosis is made and proper treatment instituted, a functionally perfect recovery may be obtained.

In certain portions of the spine, such as the mid-dorsal and upper lumbar, the deformity can be checked and in some instances lessened. In the cervical and upper dorsal region, on account of the difficulty of supporting the head, the deformity may increase in spite of the most careful treatment.

Statistics regarding the mortality are most unreliable, and vary, according to different authors, from fifteen to twenty per cent. Death is usually the result of some complication or some intercurrent affection. Tuberculous disease of the lungs, accompanying or secondary to the disease of the spine, and tuberculous meningitis are frequent causes of death.

The changes in the circulatory apparatus, due to compression or alteration of the shape of the chest, sometimes lead to fatal results. In those cases where death is not directly traceable to the spinal disease, the distortion of the chest with alteration in the course of the aorta and possibly partial obstruction of this vessel, with consequent hypertrophy of the heart and incompetency of the valves, leads to a lessened resisting power, and hence the patient succumbs under the strain of overwork, extra fatigue, or moderate illness. The largest number of deaths, however, in the opinion of the author, is due to exhaustion, with amyloid changes of the liver, spleen, and kidneys from prolonged suppurative processes caused by mixed infections.

The introduction of aseptic and antiseptic methods in the treatment of abscesses should reduce the mortality of Pott's disease nearly one-half. The opening of an abscess and the introduction of a drain, thereby allowing an abscess cavity to become infected with other organisms, or the spontaneous opening of an abscess, is, as Calot very aptly says, "an open door through which death very quickly enters."

The length of time required to bring about a cure necessarily varies with the extent and location of the disease. If the latter is diagnosed in the very early stage, before any marked destructive processes have taken place, one may hope for a cure in one year's time. If the disease is more advanced, the general condition of the patient poor, and the hygienic surroundings not of the best, the time necessary for securing a permanently fused condition of the bodies will probably be from two to four years.

Treatment.—The treatment of tuberculous spondylitis should be considered from two standpoints.

First, one should take into consideration those forces which tend to improve the general condition of the patient, thus increasing his power of resistance to the tuberculous infection, and at the same time making an unfavorable lodging-place for the tubercle bacillus. Under this head will be presented the hygienic, dietetic, and medicinal treatment.

In the second place consideration should be given to the methods of protecting the local disease process from weight-bearing and movement, thus tending to prevent the greater destruction of tissue, with increasing deformity and loss of function. Under this head will be presented the mechanical treatment.

Hygienic Measures.—That the bulk of effort has hitherto been expended in devising varied and various types of support in the treatment of Pott's disease, is manifest from the large number of such supports to be found, and the large space given to their description in most text-books. That too little thought has been given to the general or constitutional treatment, until recent years, is equally manifest from the scant notice which is given to this part of the treatment by most writers.

It has been the practice in the Hospital for Sick Children in Toronto to move all cases of tuberculosis of the bones and joints to the Lakeside Hospital, on the shore of the lake, at Toronto Island, as early in the year as possible, usually early in May. The patients sleep on the broad covered piazzas, practically out of doors, until the beginning or middle of October. The change which takes place in this class of patients is most noticeable. Before a week has been spent there, the appetite begins to improve, the patient develops some color in the cheeks, he increases in weight and must increase in resisting power; as the acuteness of symptoms begins to subside, discharging sinuses improve, and altogether the change in condition is most marked. Accurate records of weights in cases of tuberculous disease show a steady gain in practically all cases under these conditions. On the other hand, when they return to the city hospital for the winter months they barely succeed in holding stationary the gain that has taken place during the summer.

All patients suffering from Pott's disease should be put under the best hygienic surrounding. In patients of the wealthy class a sun room should be built off the living room, where the patient may spend most of the day. The bed should be sufficiently narrow to be carried through the doorway, or else a cot should be permanently arranged in the sun room so that the patient may be transferred on a stretcher from bed to cot. In case the room is unheated the mattress of the cot should be kept indoors so the patient may not be placed on a cold surface. Under less auspicious circumstances, the patient should be given a large, airy room facing the south, and the window should be open as much as possible to insure the greatest amount of fresh air. In a general or private hospital, advantage may be taken of roof gardens or other available space to get patients as much as possible in the open air.

Daily bathing, with care of the teeth, mouth, etc., also assists in promoting the general improvement of the patient.

Dietetic Regimen.—As in tuberculous disease of the chest, so in Pott's disease, there seems to be an increase in the resisting power of the individual toward the tuberculous infection, with an increase in the body weight. Hence in these cases every effort should be made to improve the nutrition, and, up to the digestive capacity of the patient, the diet should be liberal.

Milk, cream, butter, fats, with eggs, red meats, cereals, and milk puddings, should be the staple foods; and in cases of marked malnutrition the peptonized foods with malted milk may be useful. These may be distributed over the day, giving three full meals daily, with a raw egg, eggnog, cup of cocoa or bouillon between meals, and malted milk at bedtime. An accurate record of the patient's weight every two weeks should also be kept.

Medicinal Treatment.—To improve the appetite the bitter vegetable tonics may be given when necessary. Such tissue-building tonics as the phosphates and the glycero-phosphates may be of value. To render the soil an undesirable or unfavorable one for the tubercle bacillus, the arsenical preparations, and especially the guaiacol and creasote preparations, may have virtue in them, if they can be given without disturbing the digestion. If the patient is anæmic, iron in various forms and combinations may be administered, as best suits the case.

Administration of Tuberculin.—As a possibility of increasing the patient's resisting power against the tuberculous infection, may be mentioned the inoculation or vaccination with tuberculin as controlled by the opsonic index.

Sir Almroth Wright, in studying the subject, discovered that the phagocytic power of the white blood corpuscles in tuberculosis, as in many, if not in all, infectious diseases, is dependent upon a material in the blood serum which tends to prepare the bacilli for assimilation by the leucocyte. This material he called opsonin (*ὄψονω*, I prepare food for). Without the presence of this body in the serum the leucocytes apparently have no power over the bacilli. As an equation, leucocytes + bacilli = no phagocytosis, but leucocytes + bacilli + blood serum (opsonins) = phagocytosis. It was next found out that the opsonic power or opsonic index of the blood serum of the infected individual could be estimated comparatively with that of the blood serum of a normal individual, or of the pooled blood of a number of individuals. Thus a record could be kept of the opsonic power or resisting power of the individual from time to time.

The next step was the attempt to increase the opsonic power of the individual by the inoculation of tuberculin in the case of tuberculous infection, or of a sterile emulsion of the infective organisms in other infections. This, in a general way, was what happened, and if there were no side issues it would appear that one of the greatest advances of recent years had been made in the treatment of tuberculosis, as well as other infectious diseases, by this method.

Unfortunately, the problem is not yet solved; for, following the inoculation and preceding the increased resisting power, as indicated by the elevated opsonic index, there is a "negative phase" in which the index is lowered, and if another inoculation is made during this stage a second negative phase may be superadded; and so on, negative phases following negative phases, by indiscriminate inoculation, and the individual's resisting power may thus be gradually lessened. On the other hand, if the inoculations are properly controlled, and the tuberculin administered while the index is yet rising, the resisting power of the individual may be increased.

The whole story is not yet complete, however, as besides these controllable inoculations the individual may inoculate himself from time to time by toxins being set free into the blood stream from the diseased focus. This auto-inoculation may be the result of over-activity or lack of quiet; but for the most part it is an uncontrollable inoculation which may come at a very inopportune time and tend to lower resistance while an attempt is being made to increase it.

These difficulties may be surmounted in the near future, and it does seem as if we are on the eve of a revolution of the treatment of all infectious diseases by means of serumtherapy. The technique necessary to determine and record the opsonic index is too intricate to be detailed here, and it can be mastered only by those interested by research in laboratories where pathologists are doing this work.

General Principles of Mechanical Treatment.—A suggestion of the principles which should underlie the mechanical treatment of Pott's disease may be obtained by a careful observation of an acute case. In the normal spine we have a flexible rod tending to bend forward; and the superincumbent weight of the head and upper extremities rests upon the bodies of the vertebræ. Any voluntary bending forward must increase the weight on these bodies, and, conversely, any backward bending will diminish the weight. In the diseased condition of the bodies, the spontaneous attitude in the early stage is found to be one of rigidity with backward bowing or hyperextension of the spine, *i.e.*, by muscular contraction or spasm an effort is made to splint the spine, and by hyperextension to afford protection to the diseased bodies.

Any mechanical treatment, therefore, must meet these two requirements: immobilization, more or less complete, and protection from weight-bearing. It is quite obvious that by reason of the surrounding structures, which are all more or less elastic, a perfect splinting of the spine is impossible; but there may be obtained a sufficient immobilization to permit a cicatrizing osteitis to take place and a fusion of adjacent bodies if a large destructive process is present.

Recumbent Treatment.—Obviously the simplest and most efficient method of relieving the superincumbent weight is to place the patient in the recumbent position. It is not sufficient, however, simply to "put the patient to bed," as is so often done. The recumbency must be *absolute;* and during the entire time of treatment the patient is not to be allowed to sit up, or even partially to sit up. A firm mattress with a stiff woven-wire spring underneath is also an essential. If the spring is weak and the mattress soft, the patient assumes a position as in a hammock, and consequently the bending forward of the spine is permitted and pressure is not relieved. A fracture board or piece of planed board about one foot wide, placed lengthwise between the mattress and the springs, will serve to keep the patient from sagging, and will meet the requirements.

In the case of an adult this may be all that is necessary, as he can be trusted to obey instructions and will remain supine and quiet, thus meeting the requirements of protection from weight-bearing with quietness of the spine. As the bulk of patients suffering from Pott's disease are children, some method of horizontal fixation is absolutely necessary, for as soon as pain and other acute symptoms subside the child can no longer be expected to remain quietly on the back without some method of fixation. It is a distinct advantage also to have the recumbent or fixation apparatus separate from the bed, even in the adult, as then the patient may be transferred from room to room or taken out of doors, and it is possible to keep the bed in a very much better condition. The simplest apparatus for fixation of the patient in a recumbent attitude is the Bradford frame. It is a rectangular frame, somewhat longer and wider than the patient, made of gas-pipe, over which a canvas cover is tightly laced. (Fig. 715.) The patient is fastened to this frame by means of a binder which surrounds the body and is fastened to the canvas lacing. An ordinary waist answers very well as a "tie-down," the child's arms being

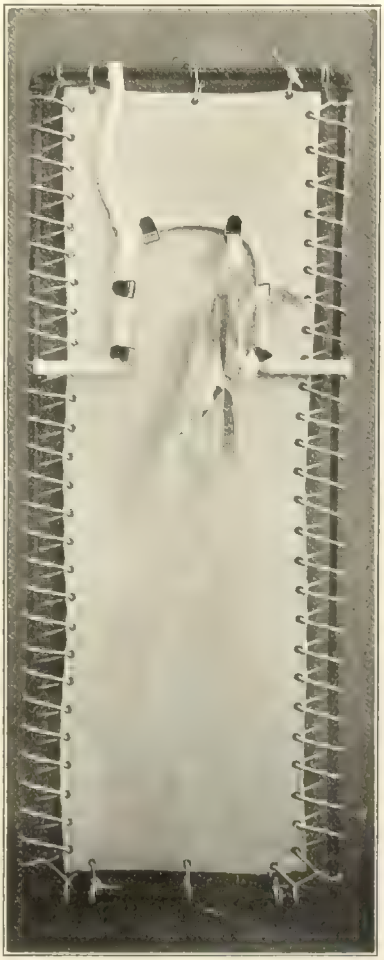


FIG. 715.—Bradford Frame, with Canvas Lacing and Gallie "Tie-down."

slipped through the sleeves or armlets, and the waist pinned above the shoulders and at the sides to the canvas. If the child pulls the pins out they may be pinned from the under surface of the lacing. At the Hospital for Sick Children, Toronto, an attachment is used, devised by Dr. Gallie, which answers admirably as a "tie-down." It hooks over the frame on either side and passes across to the body, then upward along the sides and crosses under the neck of the patient. (Fig. 715.) Buckles are attached to this cross-bar; and an apron, which fits over the child's trunk, is fastened to the buckles by means of straps. At the point where the kyphus rests on the lacing, oblong pads of felt, six inches long, three or four inches wide, and in the neighborhood of one-half inch in thickness, should be stitched to the canvas in such a way as to allow the spines of the vertebræ to project, the pressure being borne by the transverse processes. This serves the double purpose of protecting the skin over the kyphus and at the same time increasing the hyperextension of the spine by the thickness of the pads.

If the disease is in the cervical region the recumbent attitude does not relieve all pressure, on account of the forward curve in this region. It is necessary with the flat frame to add extension. This is most easily accomplished by means of a weight-and-pulley attachment at the head of the bed, the traction on the head being obtained through the Glisson chin-and-occiput sling. Counter-extension may be made by the patient's body if the head of the bed is elevated from six to ten inches.

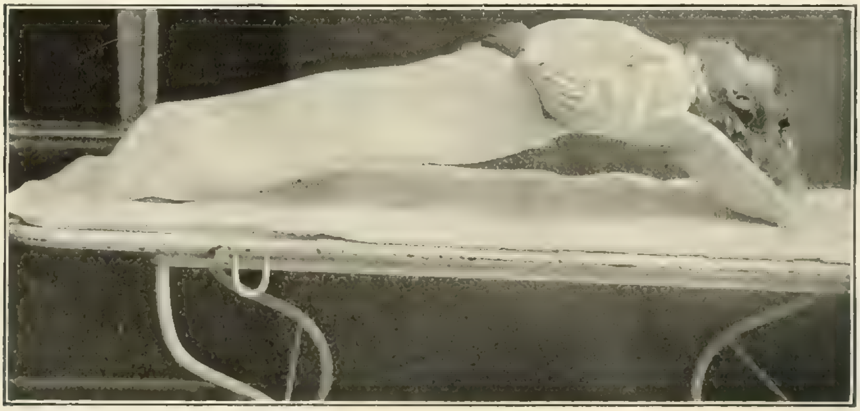


FIG. 716.—Whitman Frame, Showing Hyperextension of the Spine in a Case of Cervical Disease. (Starr.)

A very important modification of this frame has been made by Whitman. The frame as modified is much narrower, being only as wide as the patient's trunk, the shoulders and arms resting on the bed outside of the frame. It is also bent to any desired extent, so that the greatest point of convexity of the frame comes opposite the disease point in the spine. The patient's spine in this way is markedly hyperextended, the body lying over the ridge, and thus a small amount of extension is made by the portions of the spine on either side of the ridge. A moderate amount of sagging of the canvas at the maximum curvature of the frame lessens the discomfort which otherwise would be very noticeable. The curve or bowing of the frame may be moderate at first and gradually increased as the patient becomes accustomed to the position. In the cervical region the bowing of the frame may be made extreme so as to allow the head to tip backward to a marked degree. (Fig. 716.) The head of the frame may be elevated at meal-time to allow the patient more easily to feed himself. By means of a Whitman frame, a kyphus under adequate care should not only not increase, but should recede to some extent. (Fig. 717.)

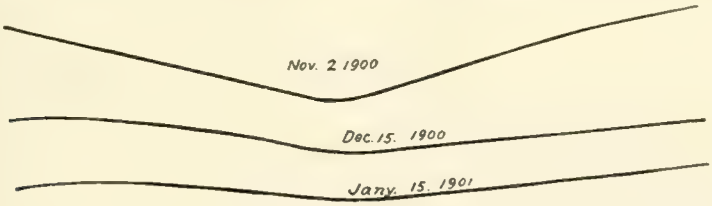


FIG. 717.—Showing Improvement in Deformity after Treatment. (Whitman.)

Care of the Patient on a Frame.—A patient on a frame which is placed on a good mattress will not be more uncomfortable than on an ordinary bed. There is the great advantage too that the patient may be moved on the frame so that the bed may be made, the mattress turned, etc. The patient should be turned on his side each day, and the back thoroughly sponged, then rubbed with alcohol and dusted with powder, such as boric-acid or talcum powder.

The canvas may be fenestrated, and so evacuation of the bowels obtained without disturbing the patient, by simply elevating the frame and placing a receptacle beneath. A slip sheet should be drawn across the canvas lacing to cover the opening. If the patient is wearing a diaper care should be exercised in putting it on, to slip it under the pelvis and not to lift the pelvis by grasping the feet, as is ordinarily done. The kyphus may increase owing to neglect of this point alone.

The objectionable features of the recumbent plan of treatment are lessened by the use of this frame and the observation of these rules. With the small frame a child may be dressed by fastening the clothes around the frame, and so carried to the open air.

All acute cases should, if possible, be treated in the recumbent position until the acute symptoms subside; that is, until the flexibility of the spine has returned and there are no pains or night starts. This will usually mean a recumbency of from four to six months, when no complications are present, and from six to eighteen months in the latter case. In all cases it is probably wise to apply the ambulatory support for a time before the patient is allowed to leave the recumbent position.

Other types of fixation apparatus may be just mentioned, as they have neither the efficiency nor the simplicity of the frame above discussed.

The Phelps bed consists of a shaped frame of wood, to fit, more or less accurately, the body and lower extremities. This has an outlying rim, and is padded well with felt and raw cotton. An opening at the perineal region permits of evacuation of the bowels without disturbing the patient. The child is maintained in the bed by bandages about the extremities and a binder about the body.

The wire cuirass, made popular by the late Professor Lewis A. Sayre, is a much lighter and more sanitary apparatus. It consists of a steel frame which outlines the patient's entire body, and to this is interwoven a wire screen or network hollowed to fit the contour of the body. It is nicely padded and the patient is bandaged to it. For infants the writer has found it very satisfactory, as the child may be enswathed very much to resemble the Indian pappoose.

The Gypsbette of Lorenz is intended to fulfil the same requirements. It is made of plaster-of-Paris bandages, which are applied to the back of the head and trunk of the patient while in a position of hyperextension, either in a hammock or by means of rolls placed under the forehead, chest, and pelvis while the patient is lying prone. This plaster, when reinforced and padded, makes a half jacket, which serves very well to keep the spine at rest and in a position of hyperextension.

Ambulatory Treatment.—Treatment by means of ambulatory supports, to be efficient and purposeful, should continue, as accurately as possible, the fixation of the spine and the protection from weight-bearing, which has been more thoroughly carried out during recumbency.

All supports should have for their object the immobilization of the spine by splinting it with non-flexible material, and the protection of the bodies by carrying the weight backward to the articular process by hyperextending the spine.

The Plaster-of-Paris Jacket.—The plaster-of-Paris jacket is at once the most readily available, easiest of application, and most widely used of all the types of support; and, if properly applied, gives equally as good support as any other. It has the disadvantage of not being capable of so accurate adjustment as the steel support, and must depend for its effectiveness on the definite moulding of it to the contour of the body. It has the advantage of staying where it is put, and cannot be altered or removed by the patient or friends. In cases of lateral deviation of the spine due to Pott's disease the plaster jacket is to be preferred to the steel support.

The plaster jacket is an antero-posterior support, and, even when applied with the child suspended, does not tend to keep the diseased surface apart by distraction; but, if applied with the spine in the hyperextended position, does tend so to fix it that the weight does not return to the diseased bodies.

Application of Plaster Jacket by Suspension.—The suspension method of application of the plaster jacket was introduced by the late Professor Sayre. The suspension of an individual by a pulley arrangement and chin-and-occiput-sling is without risk. The suspension straightens out the curves of the spine and tends also to straighten out the kyphosis, although in old cases the union or adhesion of the diseased surfaces is too strong to be separated.

A closely fitting seamless shirt should be put on, and the patient suspended just sufficiently to raise the heels off the floor or surface on which he is standing. The toes resting on the floor will steady the trunk and at the same time give it a position of hyperextension. This hyperextension may be exaggerated to any degree by an assistant holding the hips. (Fig. 718.) The easiest position in which to work satisfactorily is to have the patient standing on a stool with the operator seated behind and an assistant in front. The bandages should be made of starch-sized crinoline or bookbinder's muslin with dental plaster rubbed into its meshes, and should be about four inches wide. If the crinoline contains glue or dextrin it will retard its setting or may prevent it altogether from getting sufficiently hard to act as a support. If no other material is obtainable, the glue or dextrin may be washed out and the crinoline afterward dried and made into bandages, forming the so-called "washed bandages," which set very rapidly.

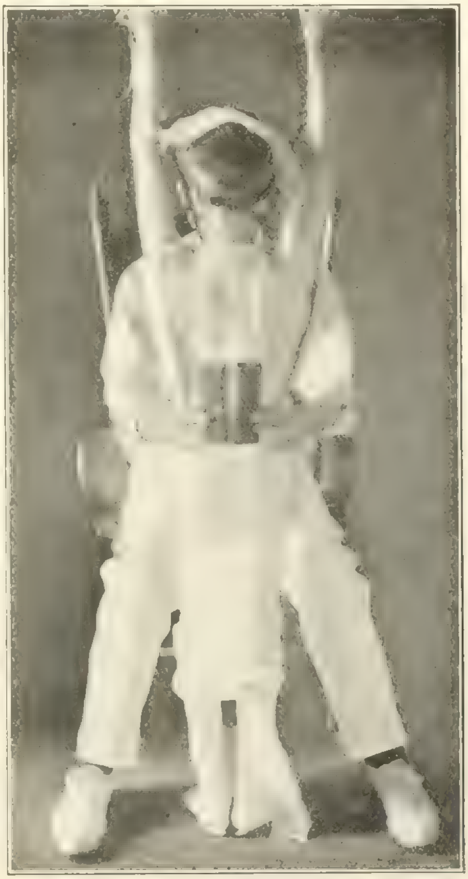


Fig. 718.—Patient Suspended by Chin and Occiput Sling, so that Heels are just off the Floor. Seamless shirting in place with pads to protect bony prominences. The "scratcher" may be seen inside the shirting extending above and below. (Starr.)

With the patient properly suspended the bandage is started smoothly and snugly around the pelvis, and several turns are applied here, each turn being well rubbed into the previous one, so as to get a firm base of support. The bandages are continued evenly up the trunk until from four to five layers are applied, making a uniform thickness of three-sixteenths to one-fourth of an inch. The jacket, to get the fullest measure of support, should reach in front from the sternal notch to the pubes, and behind from the midscapular region to the cleft of the buttocks. While the plaster is drying, if the patient is not overtired, the jacket may be trimmed. It should be cut with a sharp knife evenly across the front and back with a dip at the sides sufficiently low to allow the arms to come to the side of the body without undue pressure. At the bottom a slight concavity may be cut on either side of the middle line to allow of the flexion of the thighs; at the same time the plaster should reach sufficiently low to cover the entire abdomen so as not to allow any protrusion below. (Fig. 719.) The writer has seen several cases of hernia undoubtedly due to neglect of this precaution.

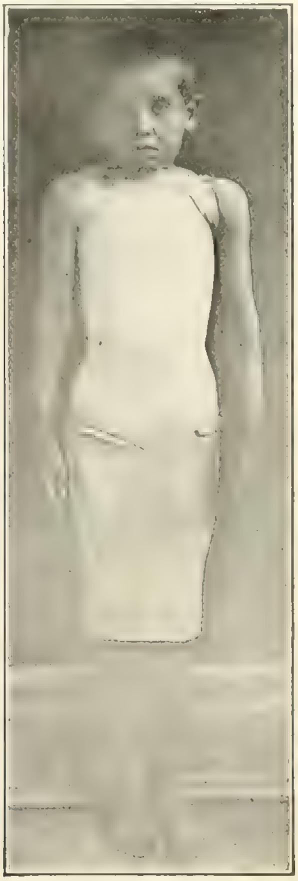


FIG. 719.

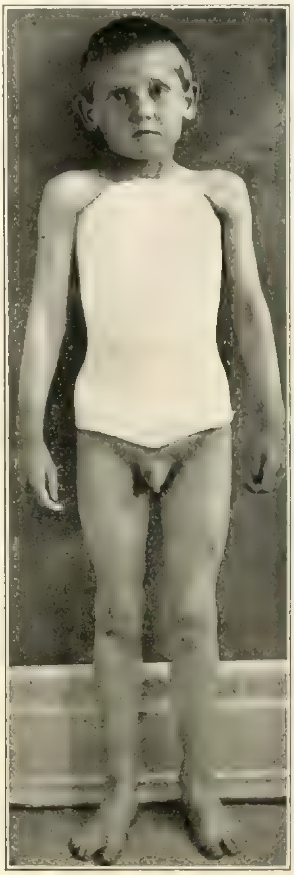


FIG. 720.

FIG. 719.—Plaster Jacket Applied, Showing Method of Trimming before Shirting is Turned up over Outside. (Starr.)

FIG. 720.—Completed Jacket; Shirting Turned up and Stitched along Upper Border. (Starr.)

After the child is removed from the suspended position, the shirt may be turned up over the jacket and stitched to the portion left above after the jacket is trimmed. (Fig. 720.) The patient should remain in the recumbent position for half an hour until the plaster has hardened thoroughly. One of the discomforts of the solid support may be lessened by placing a strip of bandage lengthwise beneath the shirt, next to the skin, to act as a cleanser. (Fig. 718.) By sprinkling alcohol on this strip of bandage and sawing it up and down a substitute for a bath is obtained. This cleanser may be renewed at any time by stitching a new strip to the end of the old one and pulling it through. The ends should be tied together to prevent its becoming displaced.

Application of Jacket in Hammock.—If for any reason it is undesirable to suspend the patient, a jacket may be put on with the child lying face downward in a hammock; the hyperextension of the spine being increased to any extent by the sagging of the hammock. A canvas or cotton hammock cloth may be attached to the ends of a gas-pipe frame, similar to the frame of a Bradford stretcher. In order to obtain the desired tension on the hammock the cloth may be attached to a windlass arrangement at one end. The patient is placed face downward on the cloth, which has an opening cut in it to allow the lower part of the face to protrude, and slits are cut longitudinally in the cloth along the sides of the body from the axilla to the pelvis. The portions of the hammock outside the slit should be cut away or fastened to the sides of the frame by means of a bandage. After the kyphus and other bony prominences have been padded the plaster bandages are applied around the patient, including the hammock, from pelvis to axilla, until sufficient thickness is

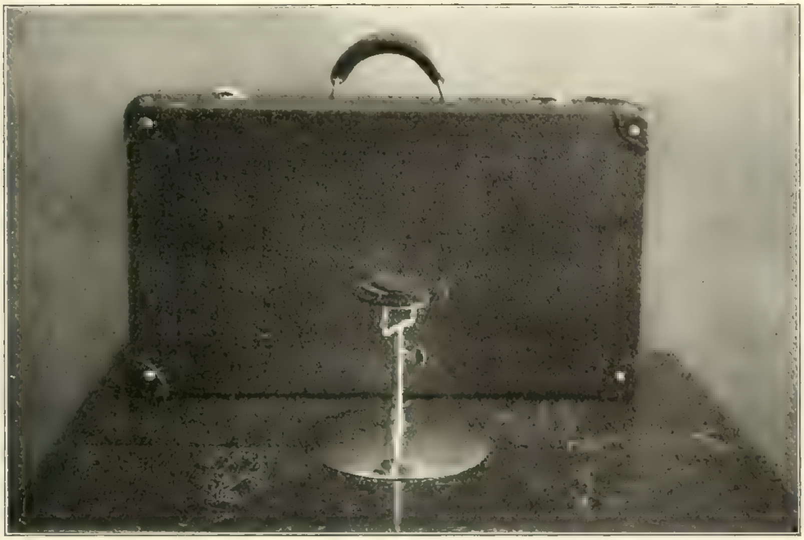


FIG. 721.—Forked Support for Application of Jacket in Recumbent Position.

obtained, when the plaster may be trimmed in a similar manner as after its application by suspension.

It will be obvious to any one applying a jacket in this way that it will be much more satisfactory when the disease involves the lower dorsal and lumbar region than when it is located in the upper dorsal, as it is quite impossible to fit the plaster accurately to the upper part of the chest in this latter position.

Application of Jacket with Patient Lying on His Back.—The flexible bars on the forked upright suggested by Goldthwait and the recumbent kyphotone of R. Tunstall Taylor were devised to allow of the application of plaster of Paris more accurately, while the spine is markedly hyperextended, than is possible by any other method.

A portable apparatus which accomplishes the same purpose is shown in Fig. 721. It consists of a steel-framed suit-case, which may be used as a pelvic rest and in which may be carried plaster bandages, stockinette, plaster-knives, and other necessaries for the application of plaster of Paris, as well as the adjustable forked upright on which the patient is supported. After the seamless stockinette or shirting is applied, the upright is adjusted by means of the thumbscrew to such a height as to produce the desired amount of hyperextension, the pelvis meanwhile resting on the suit-case and the head supported on a box or pillow. (Fig. 722.) A small steel plate well padded with piano felt is arranged on each fork of the upright so that they fit accurately the kyphus, making pressure on the transverse processes and allowing the spinous processes to project between. With the patient in this position the jacket may be applied as in the suspension method, but the posture allows of much more accurate moulding of the plaster about the upper end of the sternum and shoulders as well as about the pelvis. (Figs. 721 and 722.)

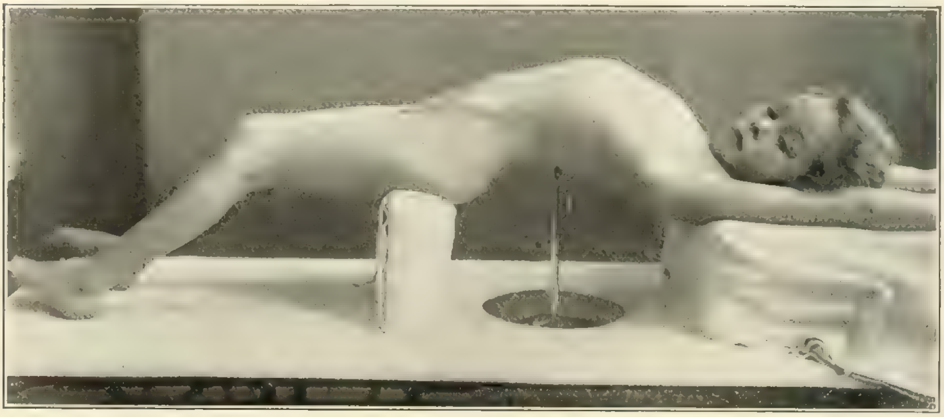


FIG. 722.—Patient in Position on Forked Support; Spine Hyperextended. (Starr.)

The padded plates are incorporated in the plaster; and when the jacket is sufficiently hard to allow of the patient's removal, he is lifted off the fork and placed with a folded pillow under the hyperextended back until the plaster is quite firm. It is trimmed in the usual way, the pins which held the padded plates being nipped off with pliers, and the small opening over the plates filled with plaster cream.

If the disease is in the region of the fourth, fifth, or sixth dorsal vertebra it is wise to include the shoulders in order to keep the backward pressure at as high a point as possible. (Fig. 723.)

The Minerva Jacket.—A patient with cervical or high dorsal Pott's disease should have the head included in any apparatus in order to secure fixation of the diseased area and to obtain the necessary hyperextension. (Fig. 724.) This form of jacket is most readily put on in the recumbent position on the back. The plaster should support the occiput and grip the forehead. The top of the head, the ears, and face are left free, and the openings are nicely trimmed around the edges. (Fig. 725.)

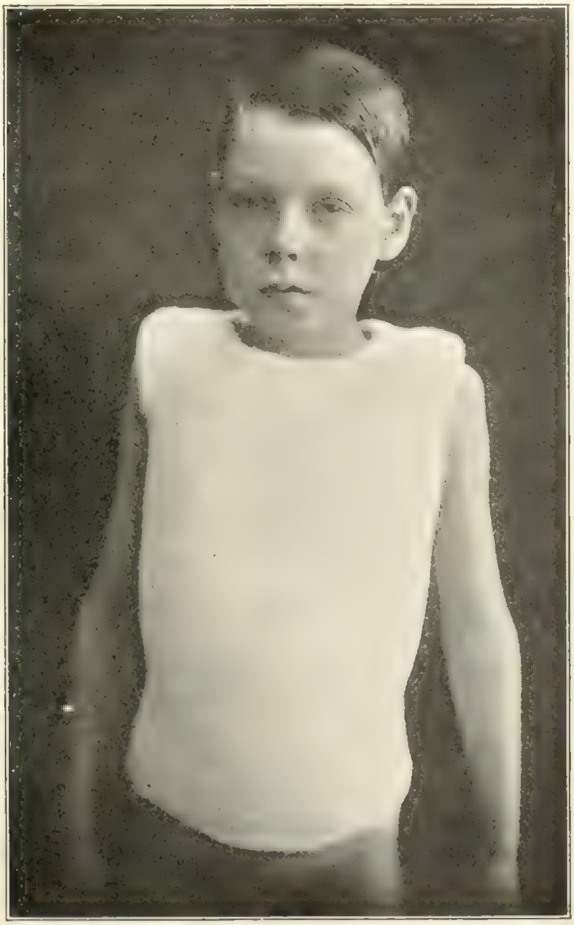


Fig. 723.—Jacket Incorporating Shoulders for Tuberculous Disease of Third to Sixth Dorsal Vertebræ. (Starr.)

The Plaster Corset.—In convalescent cases or in cases where a sinus exists, a removable corset may be made by cutting the jacket down the centre before it is completely hard. Before the plaster is applied a strip of sheet tin may be placed down the centre of the body so that in cutting the plaster down there is no danger of injury to the patient. The jacket is removed by spreading the edges and slipping it around to the side so as to get it off from the side. It is then dried for twenty-four hours, a shirt is put over the outside and stitched to the edges, and then a series of hooks attached to a leather strap is stitched to the adjoining edges to allow of its being laced up. It is put on, while the patient is suspended, by reversing the procedure of removal. (Fig. 726.)

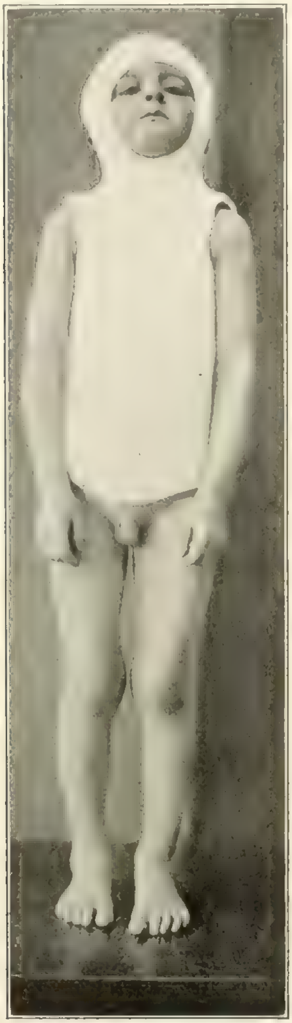


FIG. 724.

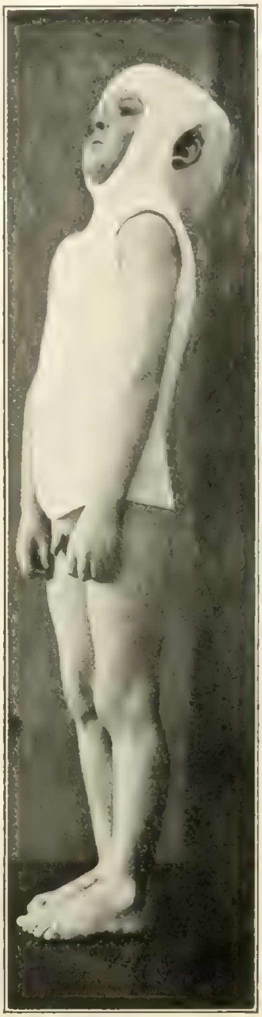


FIG. 725.

FIG. 724.—Minerva Jacket for Disease of Cervical and Upper Dorsal Vertebræ. (Starr.)
FIG. 725.—Side View of Minerva Jacket. (Starr.)

Steel Supports.—The various steel supports have for their object the fixation, as completely as possible, of the spine. Of all the appliances suggested, the steel brace devised by Dr. C. F. Taylor, of New York, is probably the most efficient as well as the simplest. It is an antero-posterior support, having a fixed point at the pelvis. The pelvic band may be a flat band of steel passing around the pelvis just between the crest of the ilium and the tip of the trochanter, and encircling a little more than the posterior half of the pelvis, or it may be in the shape of an inverted U, the arms reaching downward as far as possible, and allowing the patient to sit down. The front half of the pelvic band may be made as a leather belt, or the lower end of the apron which covers the abdomen may be attached to the ends of the band. From this fixed band two non-flexible steel uprights pass upward on either side of the spinous processes to the *vertebra prominens*, where they end by being riveted to a short cross-band of steel. Over the kyphus a special pad is attached to the uprights to make adequate pressure over the diseased area and at the same time to protect the skin. From the cross-bar at the top, two shoulder pads rise over the shoulder on either side of the neck. (Fig. 727.) The body is fastened into this support by means of an apron which is attached to the shoulder pads, and, by means of webbing straps around the chest and margin of the ribs, to the uprights.

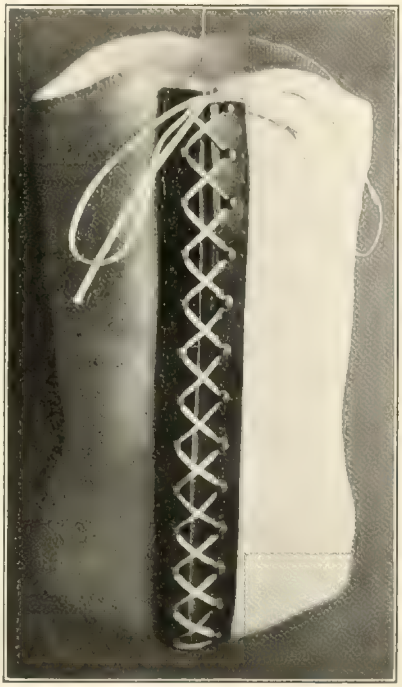


FIG. 726.—Plaster-of-Paris Corset. (Starr.)

The difficulty of holding the upper part of the trunk firmly back to the support has been recognized, and many suggestions have been made to overcome it. Whitman has an additional pad placed over the head of each humerus. These pads, which are joined together by a steel or hard-rubber bar, are fastened to the shoulder pad on top and, by means of axillary bands, to the uprights. In the Hospital for Sick Children, Toronto, a similar device is used, but it is attached to, and made part of, the apron. (Fig. 728.) It is obvious that to be efficient this support must be accurately fitted. A tracing of the spinous processes is made, by means of a lead tape, the patient meanwhile lying on his face. This gives the mechanic a guide to the shape of the uprights. After the support is made in the rough it should be fitted, any alterations being easily made with wrenches by the surgeon himself. The patient should never be turned over to an instrument maker to furnish a support, as a thorough knowledge of the anatomy and the pathology of the disease is necessary to its perfect adjustment. The support should be worn day and night. It should be removed once a day with the patient lying on his face or side, when the back should be bathed, rubbed with alcohol, and powdered with talcum powder. If, in spite of this care, the back gets chafed and sore, the splint must be removed and the patient kept recumbent for a few days until the skin is healed.

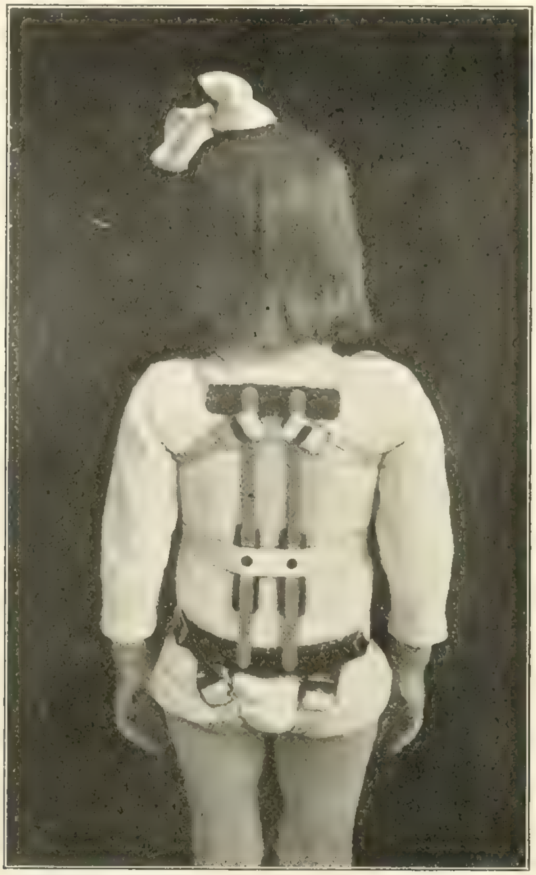


Fig. 727.—Taylor Spinal Support Applied. (Starr.)

The patient should be seen at intervals and the splint readjusted when necessary, as the growth of the child or the increase or recession of the deformity would naturally cause a misfit.

Head Supports; Jury-mast.—The maintenance of protection and fixation is very much more difficult when the disease is in the cervical or upper dorsal region, as some method of supporting the head must be introduced. With the plaster-of-Paris support, instead of the Minerva headpiece, a jury-mast may be attached. (Figs. 729 and 730.) It is made of a piece of band steel incorporated into the jacket behind, and extending upward over the head, with a cross-bar fixed at the end. To the cross-bar a chin-and-occiput sling is attached, and when the side straps are tightened a fair suspension of the head is obtained. The jury-mast is difficult of accurate adjustment, it is very unsightly, and altogether, it is not a very satisfactory method of supporting the head. The fixation also produced by this type of support is not adequate, although the results obtained with careful watching are very satisfactory.

A greater degree of fixation may be produced by making the cross-bar stationary. This should be done if the disease is in the cervical region, but is unnecessary if the disease is in the dorsal region. When accurately adjusted the spring should reach nearly to the frontal region or to a point just in front of the ears. The supporting sling should have the chin straps tightened sufficiently to tilt the chin slightly upward and extend the spine.

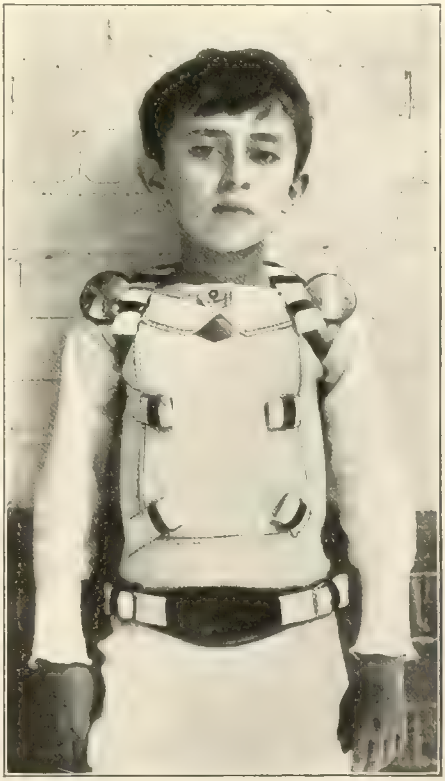


Fig. 728.—Anterior View of Taylor Spinal Support. Showing apron and shoulder pads. (Starr.)

Occipital Support.—With the plaster jacket or a Taylor spinal support as a base, a band of steel may be carried closely up the back of the neck and head to the occipital protuberance with a U steel band attached to its upper end, reaching forward to the external angular process of the frontal bone. This occipito-frontal band is completed with a leather strap, and, if the upright bar is bent backward, fixation and extension may be satisfactorily obtained. (Figs. 731 and 732.) If the patient is difficult to control, additional firmness is secured by running another steel band from the nape of the neck obliquely upward over the mastoid processes to join the horizontal steel band at its anterior ends. A chin strap may also be added if thought desirable. (Fig. 733.)

Taylor Chin Cup.—The head support suggested as an addition to the Taylor spinal brace consists of an oval ring of flat steel, hinged at one side and having a catch lock on the other, so that it may be fastened around the neck. (Fig. 734.) This ring is attached to the upper end of the ordinary steel support by means of a ball-and-socket joint. To the anterior portion of the oval ring is fitted a hard-rubber or padded-aluminum chin cup, into which the chin sinks. By means of the ball-and-socket joint at the back any desired elevation of the chin may be obtained. This support can be made to carry out the principles laid down for the treatment of disease of the spine and is certainly much more graceful in appearance than the jury-mast. (Fig. 735.)

If it is worn for a great length of time it causes a recession of the chin and gives a very weak expression to the child's face. It is difficult also to protect the skin of the chin, as, when eating, the food and drink tend to run down into the cup, and a chafing or excoriation of the chin results.

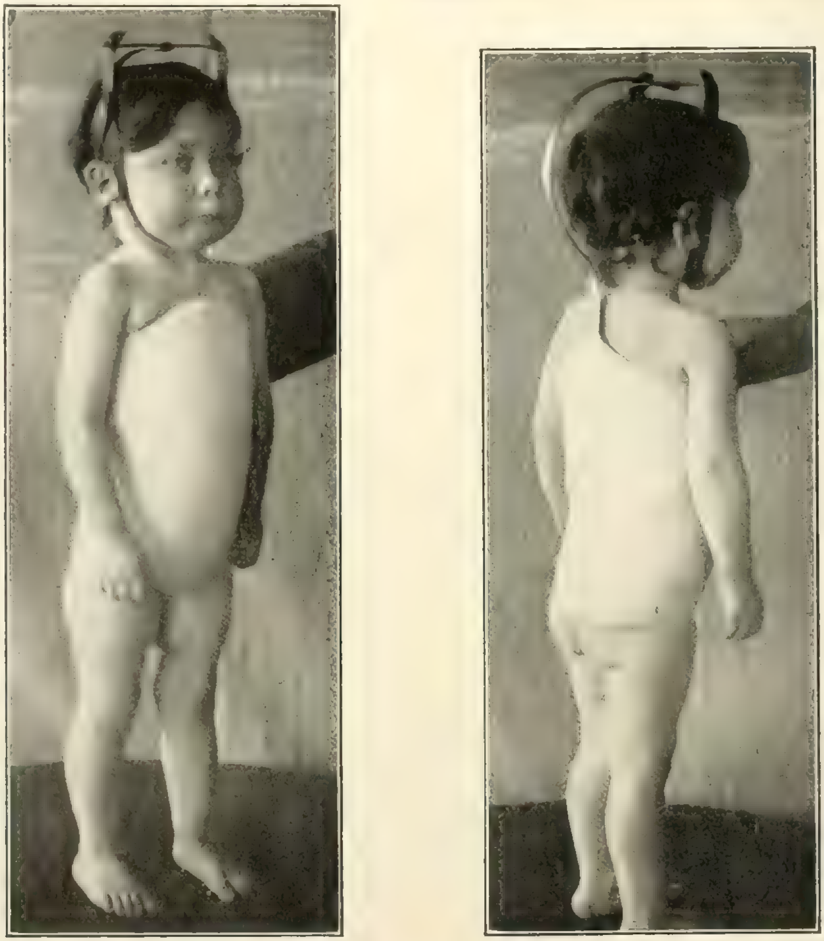


FIG. 729. FIG. 730.

FIG. 729.—Plaster Jacket with Jury-mast. (Starr.)
FIG. 730.—Posterior View of Jacket with Jury-mast. (Starr.)

Thomas Collar.—A collar made of leather and stuffed with dry sawdust was introduced by Thomas of Liverpool. It is made of soft leather sufficiently wide so that when stuffed it will rest upon the clavicles, sternum, and muscles of the neck below, and support the chin and head above. To give a large measure of support it must be repadded from time to time.

Poroplastic Collar.—At the Hospital for Sick Children, a support is used which rests upon the shoulders below, and supports the chin and occiput above. It is made by cutting, out of poroplastic material, a shape which will fit as a cape over the shoulders and about the neck. This is heated in the oven, and then, while soft, it is moulded about the neck and shoulders of the patient over a shirt so as to prevent a burn. It is subsequently trimmed and bound around the edges, the inside being padded if so desired, and a lacing made up in front. A chin cup is supported from two uprights at the front, these uprights being adjustable to any height by means of a thread and thumb-screw. An occipital support is fastened to a single upright behind, which may be jointed to facilitate its application. (Fig. 736.)

Corsets.—Corsets of other material than plaster of Paris may be used. The *leather corset* has the advantage of being more durable. It is, however, more difficult to make and much more expensive, and is difficult to make so that it will not creak on movement. A plaster jacket is applied in the usual way, and when partially hardened it is cut off and then bandaged together. From this mould a cast is made by filling it up with plaster. About the cast, light sole leather, previously softened by soaking for twenty-four hours in water, is stretched and tacked. It is allowed to dry and then it is trimmed, holes are punched in it to make it porous, and hooks are fastened along the edges in front to lace it. The jacket hardens as it dries and becomes very firm. The stiffness may be increased by painting it with two or three coats of shellac.

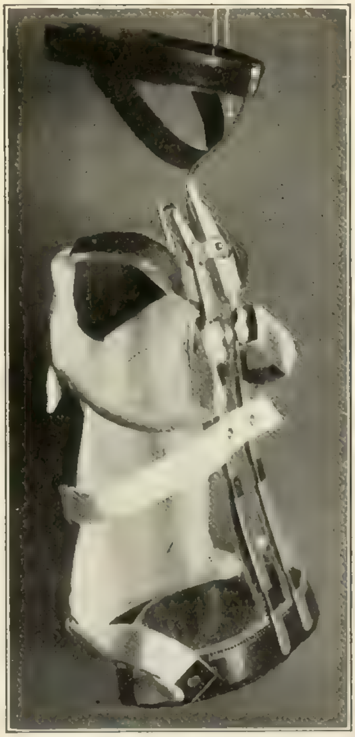


Fig. 731.—Occipital Support Attached to Taylor Spinal Brace. (Starr.)

The *celluloid corset* is very light, and clearly would make an ideal support if it could be easily handled. The celluloid is obtained in sheets and must be moulded over the cast while very hot, after soaking in hot water. To protect the hands of the operator, rubber gloves may be worn. After it has dried, holes are punched in it, and it is completed in the same manner as the leather jacket. This corset warps very easily and thus readily loses its shape. It is also very inflammable.

Wood-fibre and *paper corsets* are also made, but have not sufficient advantages over the plaster to warrant one in spending the time or energy necessary to make them.

Choice of a Support.—In the choice of a support the matter of expense should be considered. The plaster-of-Paris jacket is the cheapest form of support that can be made. If the patient is not likely to receive careful attention, a solid plaster jacket is the support which can be least meddled with, and requires the least care. If the parent of the patient can be trusted to care for it a steel support carefully fitted gives the best and most comfortable support. It allows of better care being taken of the skin. The skill of the operator must also be considered. Some surgeons cannot succeed in putting on a well-fitting plaster-of-Paris jacket. The deformity increases, pressure sores result, and the whole affair is a general misfit. The writer has seen a poor weak child suffering with Pott's disease afflicted with the additional burden of carrying around a band of plaster nearly three-quarters of an inch in thickness and reaching only from the nipple line to the crest of the ilium. This type of jacket only blinds the eyes of the parents, deludes the surgeon into thinking that something is being done, and in the end is harmful to the little sufferer.

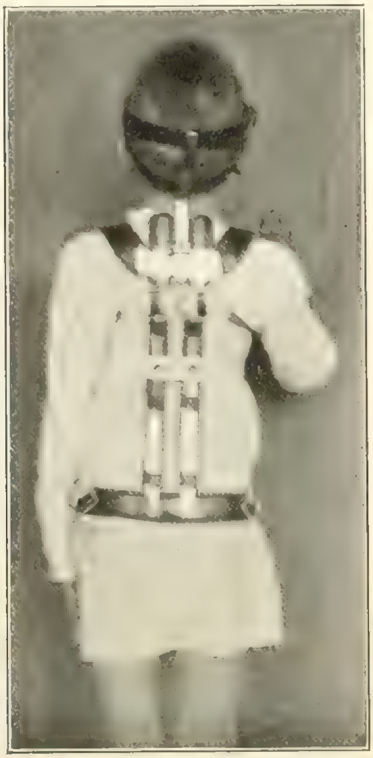


Fig. 732.

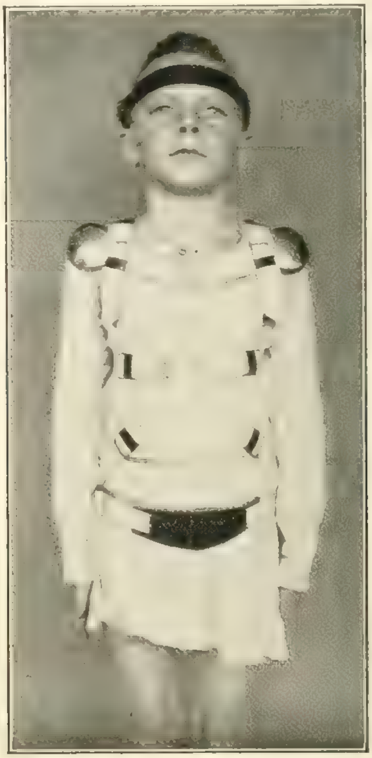


Fig. 733.

Fig. 732.—Occipital Support for Disease of Vertebræ in Cervical Region. (Starr.)
Fig. 733.—Showing Fixation of Shoulders and Extension of Spine: with frontal strap. (Starr.)

When to Discontinue Supports.—It is most important, and also most difficult, to know when a spinal support may be safely discontinued. Some general principles may be laid down which will be of assistance in deciding this question. In any case of undoubted Pott's disease the treatment should not be discontinued within one year. If the disease is more extensive, particularly if accompanied by abscess formation or paraplegia, treatment should be continued for probably three years. When no abscess exists, when all muscular spasm has subsided as determined by the hyperextension of the back by elevating the feet when the patient is prone upon the table, when no pain is present, and at least a year has elapsed since treatment was started, then the support may be gradually left off, the patient being carefully watched from day to day and symptoms noted.

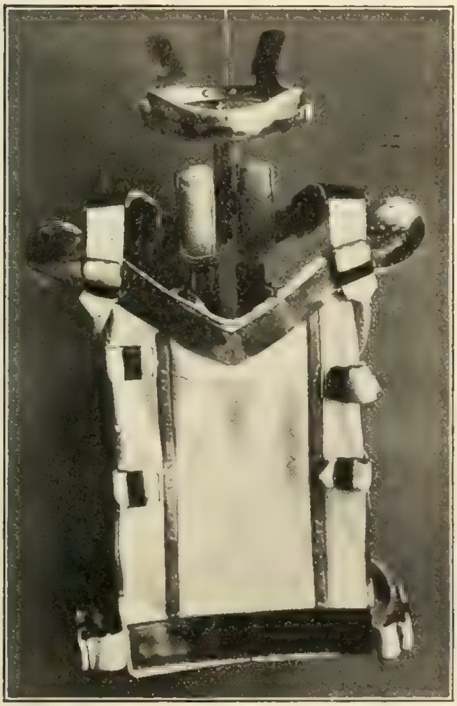


FIG. 734.

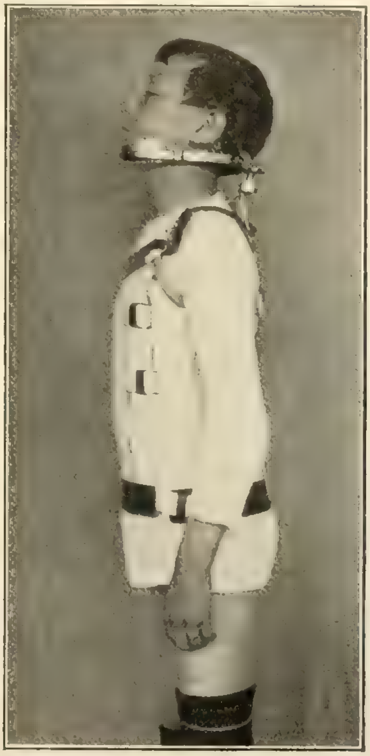


FIG. 735.

FIG. 734.—Taylor Chin Cup for Support of Head in Disease of Cervical Vertebræ. (Starr.)
FIG. 735.—Chin Support, with Taylor Brace. (Starr.)

The support might be left off at night for a time and worn in the daytime, and then gradually left off for a longer and longer part of the day, and finally discarded altogether. When the support is reapplied the position of the patient should be similar to that in which he was when the support was first put on; otherwise proper support will not be had and discomfort, possibly pain, may result, and lapse of deformity may take place.

If examination of the spine shows that there is increasing flexibility and freedom of movement from day to day and week to week without pain or discomfort, then the patient may be considered safe. If, however, the movement of the spine becomes more limited as time goes on and there is complaint of weakness and pain, then it is apparent that the support has been left off too soon, and it should be replaced.

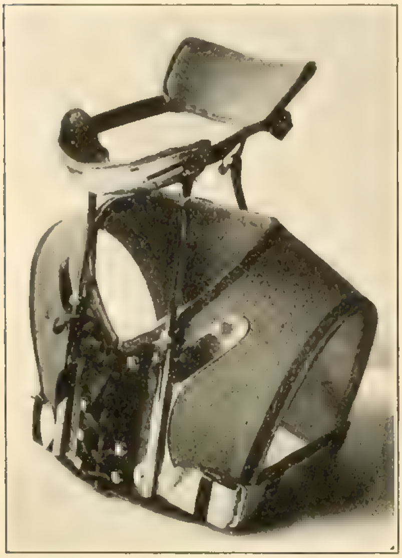


Fig. 736.—Chin Support, with Poroplastic Collar. (Starr.)

Treatment of Complications.

Treatment of Tuberculous Abscess.—*Expectant Treatment.*—It is well known that if properly treated, a certain proportion of abscesses disappears in patients suffering with a tuberculous bone lesion. The fluid portion of the abscess is absorbed and the caseous matter left becomes encapsuled, and all evidence of abscess, except some fibrous thickening, disappears. This being the case, it certainly is the part of wisdom to watch all abscesses, while at the same time the spinal lesion is adequately protected and the general condition of the patient is built up by out-of-door life, abundant and nutritious diet, and general tonics of tissue-building type.

In this connection the writer feels justified in making the statement that all tuberculous bone lesions with abscess formation can be more efficiently treated in the recumbent position than by any ambulatory plan, and it has become the custom here to put such patients in the recumbent position with absolute fixation, in the hope that the abscess will be absorbed.

The question next arising is, what symptoms will warrant one in giving up the expectant plan and resorting to more radical measures. The most significant symptom will be the steady increase in the size of the abscess in spite of general and protective treatment. If the abscess does enlarge it does not necessarily mean that the bone lesion is getting more extensive and that the increased abscess content is due to bone débris. On the contrary, we know that the bone focus is often quiescent, and that the increased size of the abscess is due to invasion, by the tubercle, of the soft tissues, the breaking down of which forms the bulk of the abscess contents. This invasion of soft tissue is often more difficult to get rid of than the original focus.

The line of least resistance is followed by the gradually increasing mass and, eventually, it will work to the surface.

This is the crucial point in the consideration of the treatment of these abscesses. If the abscess be allowed to open spontaneously it will of course become infected very quickly with septic organisms, and we then have the danger element which we are anxious to avoid. On the other hand, if the abscess burrow too close to the skin, one of two things may happen—the abscess may become infected with organisms from the hair follicles or sweat glands, or the skin itself may become invaded with the tuberculous disease.

The point especially to be emphasized is that surgical interference should take place before either possibility becomes a fact.

Aspiration.—There are a number of favorable features about this plan: It can be resorted to without an anæsthetic and the shock of an operation, it minimizes the possibility of mixed infection, it lessens tension in the sac and thus reduces the tendency to extension of the abscess.

There are, however, a number of disadvantages. It withdraws only the liquid portion of the contents, and the subsequent action of the bacilli or toxins causes a liquefaction of the caseous material, so that the process must be repeated, sometimes on several occasions. A second objection is that very frequently the needle plunges into a caseous mass and at once becomes plugged, and the result is a "dry tap." It very rarely happens that any large quantity of the liquid contents is withdrawn before the needle does become plugged, and this second mechanical difficulty is a most annoying one. Again, on the withdrawal of the needle the abscess contents are apt to follow in its track, and a tuberculous track results which will ultimately break down and form a sinus.

Injection of germicidal agents, with or without the withdrawal of any of the abscess contents, does not seem reasonable; as any agents which may safely be injected into a closed sac without endangering life can scarcely be expected to have any beneficial effect. The plan has few advocates, and while it is not open to the objection of adding a mixed infection it does not seem to offer any adequate hope of getting rid of the outer diseased wall.

Incision and Drainage.—This is the common method of treatment advocated by most text-books, even the most recent works on orthopedic surgery and diseases of bones and joints. It is the method commonly given by students when asked for treatment of tuberculous abscess. The abscess, or more properly tuberculous cyst, is treated exactly like any ordinary septic abscess: often without any aseptic precautions whatever. This always results in a long-continued discharging sinus, with frequent painful dressings, foul discharges, and the serious chain of symptoms previously outlined, often endangering the life of the patient and always making his condition annoying. The single sinus often becomes closed, only to find a new outlet elsewhere, until the seat of the disease becomes riddled with sinuses.

Incision, Evacuation of Contents, Curetting of Wall, and Closure of the Wound.—The aseptic incision of the tuberculous abscess, in two or more positions if necessary, the careful evacuation and wiping out of contents and abscess wall, with the closure of the wound or wounds, have been advocated and practised for a number of years by the writer.

The results as compared with any other method are, in my experience, vastly superior. If the wound fails to unite because of tuberculous infection of the edges or because the coapted surfaces are too thin, the result is still as good as if incision alone were resorted to.

The technique of the method is to have the region thoroughly prepared, as for any aseptic operation. The abscess is then incised freely, the contents are thoroughly evacuated, the wall is gently curetted with a Volkmann spoon when that may be safely employed, and the cavity is wiped out with iodoform gauze, as much of the abscess wall being removed as possible. The edges of the wound are then carefully cleansed to free them of any tuberculous infection, and brought together with deep sutures in order to approximate as wide areas of tissue as possible. A dry antiseptic dressing is then applied, with pressure over the region of the abscess to assist in the obliteration of the space which it occupied.

The writer's series covers sixty cases of tuberculous abscesses treated in this way, nine of which afterward broke down, while fifty-one, so far as they can be traced, have remained perfectly closed for from six months to five years. Two or three of those which broke down are accounted for by the fact that the abscess had burrowed too close to the skin and the skin had become infected. This could be guarded against in future by excising the diseased skin. In one or two instances this infection resulted from opening the abscess through the thinned part, instead of making the incision through deeper structures so that a wider, healthy surface could be coapted in closing the wound. The greater the depth of healthy tissue one can keep between the abscess sac and the outside skin the more perfect will be the result. Even in these nine, the result was no worse than it would have been had the wound been left open, while the other fifty-one were spared the possibility of danger and the annoyance of frequent dressings.

A ten-per-cent emulsion of iodoform in sterilized glycerin was formerly poured into the cavity after evacuation of the abscess contents, but this has been abandoned on account of the dehydrating effect of the glycerin on the tissues and the consequent filling up of the cavity with serum. To be sure the serum is soon reabsorbed, but in some instances, at least, the filling up with fluid in the first few hours is enough to endanger the line of sutures and force open the wound.

Von Mikulicz claimed that the iodoform has a specific effect on the tubercle bacillus. The experience of the writer and of others (as Sherman of San Francisco) does not seem to bear this out. In any case the wiping out with ten-per-cent iodoform gauze must leave a fair amount of iodoform behind it without leaving the harmful glycerin.

A retropharyngeal abscess, if producing serious dyspnœa, should be opened through the mouth. A bistoury blade should be covered to within half an inch of its point and the abscess freely opened. Care should be taken to have the head low so as not to allow of inhalation of the pus into the trachea. If the abscess is causing no marked obstruction to the breathing, it may be reached from the posterior triangle of the neck. In this way the risk of infecting the abscess cavity is minimized and there is no danger of producing a septic pneumonia.

A mediastinal abscess is difficult to locate, and difficult to reach after it is located. The only way to evacuate such an abscess is to make an incision longitudinally through the skin, over the line of the transverse processes, and separate the fibres of the erector spinæ muscle down to the ribs. Two or three ribs may be divided at their tubercles and removed with the transverse processes of the adjoining vertebræ. The fingers are then inserted and after the pleuræ have been separated the anterior surfaces of the vertebræ are explored and the abscess opened.

Treatment of Sinuses.—After an abscess connected with the spine has become infected, the cavity will continue to discharge for months and sometimes for years. The original sinus may close up, only to have the discharge break out elsewhere. The usual method of treatment of a septic cavity is to see that the sinus leading to it is free, so that adequate drainage is established. As the bone lesion becomes quiescent the sinus will fill up with granulation tissue from the bottom, and closure by this means is likely to be permanent. To establish this perfect drainage, a tube of rubber answers the purpose better than one composed of any other material. If the sinus is long, as in the case of a high psoas abscess, a catheter of good calibre, with several openings made in the side, will follow the tract better than a plain rubber tubing. Gauze, unless rolled in rubber tissue, does not make an efficient drain, especially if it is "packed" into the sinus, as is usually the case. A single strand of gauze carried to the bottom of the sinus, and the outer end kept moist, will establish a capillary drain, but the sinus closes in from the side, and soon it is difficult to get the gauze to the bottom. A tube will be gradually crowded out by the granulations, and can be cut off from time to time as necessary.

The Bier method of treatment of sinuses or infected spaces by hyperæmia, has proven very successful in many hands. The hyperæmia is produced in the case of a tuberculous sinus by a cupping or suction apparatus. The cup is applied over the mouth of the sinus, a vacuum is produced by means of the rubber bulb, and a resulting congestion of the sinus wall, with evacuation of the contents of the sinus, is produced. The cupping is continued for from three to five minutes, followed by a like interval; and then the cup is reapplied, until, in all, a half-hour's congestion has been kept up. This process is repeated every twenty-four hours. The result is that frequently the granulations are stimulated;

and as the discharge is removed at the same time, the sinuses which have stubbornly resisted all treatment close up. The reason for the beneficial results obtained by hyperæmia of the part is difficult to discover, but may possibly be accounted for on the hypothesis of Wright, that it increases the number of white blood corpuscles and therefore increases the phagocytic action with consequent destruction of the infective organisms. At the same time that improved drainage is being maintained, and hyperæmia of the part is being continued, the general condition of the patient should be improved to the utmost degree by keeping him in the open air, increasing nutrition by a forced diet and by the giving of tissue-building tonics.

Treatment of Paraplegia.—The percentage of recoveries without operative interference is very large. In a series collected by Little, Lorenz, Wullstein, Lovett, Dollinger, and Vulpius, 62.5 per cent recovered. Taylor and Lovett found that in forty-seven cases of paraplegia occurring in private practice, eighty-three per cent recovered.

In a case where paraplegia is expected, the patient should be put in the recumbent position, either in a solid plaster-of-Paris jacket or in a Gypsbette of Lorenz, with the spine in a position of hyperextension. If the disease is advanced, and there is complete paraplegia with spasm of the muscles and flexion deformity, extension may be made from both lower extremities by means of the adhesive plaster extension and pulley apparatus. Counter-extension must be made on the head by means of a chin-and-occiput sling attached to a weight over a pulley at the upper end of the bed.

In cases of cervical or high dorsal Pott's disease with paraplegia, it may be sufficient to make extension by means of the chin-and-occiput support with elevation of the head end of the bed, so as to make a counter-pull by the weight of the body.

Potassium iodide seems to have a beneficial effect on a great many of these cases. It is best administered after meals in a little milk. If a solution is made so that each drop represents a grain of the potassium salt, as much as three or four grains may be given three times daily at first, and the dose increased a drop each day until symptoms of iodism appear. Children develop a marked tolerance of the drug when given in this way. One patient of the writer was given as much as four drachms a day for several weeks without showing any symptoms of iodism or disturbance of the stomach.

Operative Treatment.—In some cases which resist the expectant or recumbent treatment, it may be suspected that a spicule of bone is making pressure on the cord and keeping up the nervous symptoms, or that an abscess may have burst through the posterior wall of the vertebral body and that its presence keeps up the symptoms. In these instances a laminectomy may be advised. An incision is made in the middle line over the spinous processes, and the erector spinæ is stripped from the spines and laminæ by means of a periosteal elevator. With a cutting bone-forceps the spines of the three or four vertebræ at the kyphus are nipped away, and with a laminectomy forceps the laminæ are divided on each side and removed. It is not necessary, as a rule, to open the dura, which is now exposed. The surface of the neural canal should be explored with a bent probe and any spicule of bone removed, or abscess evacuated. The wound should be closed with a small drain left in the most dependent portion for twenty-four hours to prevent any accumulation of blood about the cord. The patient should lie upon the face for a time, until the wound is healed. The chest and pelvis may be supported on pads or pillows so as to keep the spine somewhat extended.

Calot's Operation.—The operation of forcible redressement of the deformed spine was performed by Hippocrates and later by Ambroise Paré. In 1896 Calot of Berck-sur-Mer revived the operation, and a large number of cases were so treated. The patient is anæsthetized and placed face downward upon two cross-benches well padded, one under the chest and the second under the pelvis. While forcible extension is made by assistants upon the arms and head in one direction, extension is made in the opposite direction upon the feet by more assistants, and the operator makes strong manual pressure downward on the kyphus. The kyphus is easily broken down and the deformity overcome. A plaster-of-Paris jacket is then applied to maintain the spine in the corrected attitude. This support is continued for from nine months to several years.

At the time of the operation a gap must be made by the separation of the fused vertebral bodies. It was thought that this gap would fill up with bony tissue, but such has not proved to be the case; as only fibrous tissue filled up the gap, and in a great majority of the cases the deformity gradually returned. The mortality, immediate and remote, of the operation was so great that it has been practically abandoned. Extensive and fatal hemorrhage took place in some cases; meningitis, rupture of the pleura, and pneumonia caused many deaths; and the favorable results were not such as to warrant the continuance of the operation.

In some cases of paraplegia, the paralysis was relieved by the operation, but the same relief can be obtained by the gradual redressement which takes place with the patient in a position of hyperextension of the spine on a Whitman frame, or in a plaster jacket applied in a hyperextended position of the spine and changed frequently, to increase the degree of hyperextension.

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